DOCUMENT RESUME

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Descriptors- *Aerospace Technology, Earth Science, *Elementary School Science, Fine Arts, Industrial Arts, Language Arts, Mathematics, *Reference Materials, *Resource Materials, *Secondary School Science, Social Studies

This resource guide is intended for teachers of all subjects at all grade levels. It is a compilation of space related information designed to parallel and reinforce the topics and concepts normally taught. Each of the nine chapters concerns the use of this information in a specific area of education such as language arts, fine arts, industrial arts, social studies and science at the various grade levels. The volume is appended with a section devoted to the various teacher education programs sponsored by NASA. Each chapter contains sections devoted to learning activities, references and resources, and suggestions for reinforcement activities. Many learning activities are carefully illustrated and the book abounds in space age photographs. (BC)

AEROSPACE CURRICULUM RESOURCE GUIDE

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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SE 006 272

MASSACHUSETTS DEPARTMENT OF EDUCATION
IN COOPERATION WITH
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

AEROSPACE CURRICULUM RESOURCE GUIDE

The teacher seeking ideas and sources will find that the

TOPICS (fundamental concepts in basic subject areas drawn from the aerospace program),

LEARNING ACTIVITIES (projects designed to promote student involvement in basic subject areas),

REINFORCEMENT (enrichment for students and teachers when interest and time permits),

and

REFERENCES and RESOURCES (a broad range of additional background information)

presented in this resource guide are keyed, using bold letters for quick reference, to grades in Elementary School kindergarten through 3rd grade **(K-3)**, Elementary School 4th grade through 6th grade **(4-6)**, Junior High School **(7-9)**, and High School **(10-12)**

It is fully recognized that as this document entered the usual printing preparation stages, the national space program continued to make rapid and significant progress. The entire NASA program is perforce fastmoving so that what happens today is reinforced and changed by the events of tomorrow.

Each teacher who may use this guide should supplement its content by contacting the Education Officer serving his state as listed to the right. He will be glad to provide the very latest information available, including a current Film List and Educational Publications List.

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

All NASA films, NASA Educational Publications (EP), and NASA Facts (NF) listed in this resource guide may be obtained by writing to the NASA Center which services the area in which your school is located.

For Schools in	*Write to Education Office at:*
Alaska, Idaho, Montana, Northern California, Oregon, Washington, Wyoming	NASA Ames Research Center Moffett Field, California 94035
Connecticut, Maine, Massachusetts, New Hampshire, New York, Rhode Island, Vermont	NASA Electronics Research Center 575 Technology Square Cambridge, Massachusetts 02139
Alabama, Arkansas, Louisiana, Mississippi, Missouri, Tennessee, West Virginia	NASA George C. Marshall Space Flight Center Marshall Space Flight Center, Alabama
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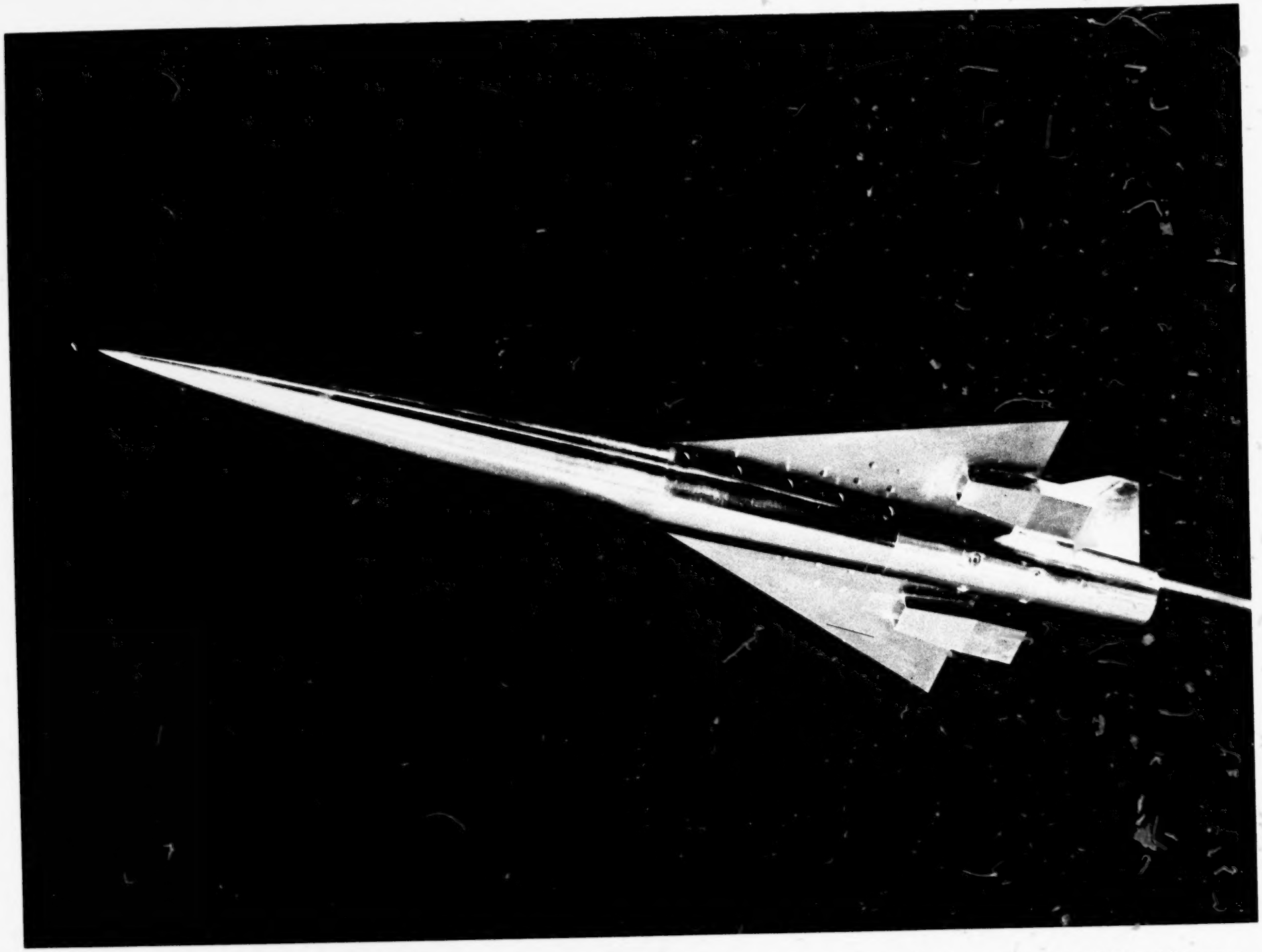
Illinois, Indiana, Iowa, Michigan, Minnesota, Ohio, Wisconsin	NASA Lewis Research Center 21000 Brookpark Road Cleveland, Ohio 44135
Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, Texas	NASA Manned Spacecraft Center Houston, Texas 77058
Arizona, Hawaii, Nevada, Southern California, Utah	NASA Pasadena Office 4800 Oak Grove Drive Pasadena, California 91103

AEROSPACE CURRICULUM RESOURCE GUIDE

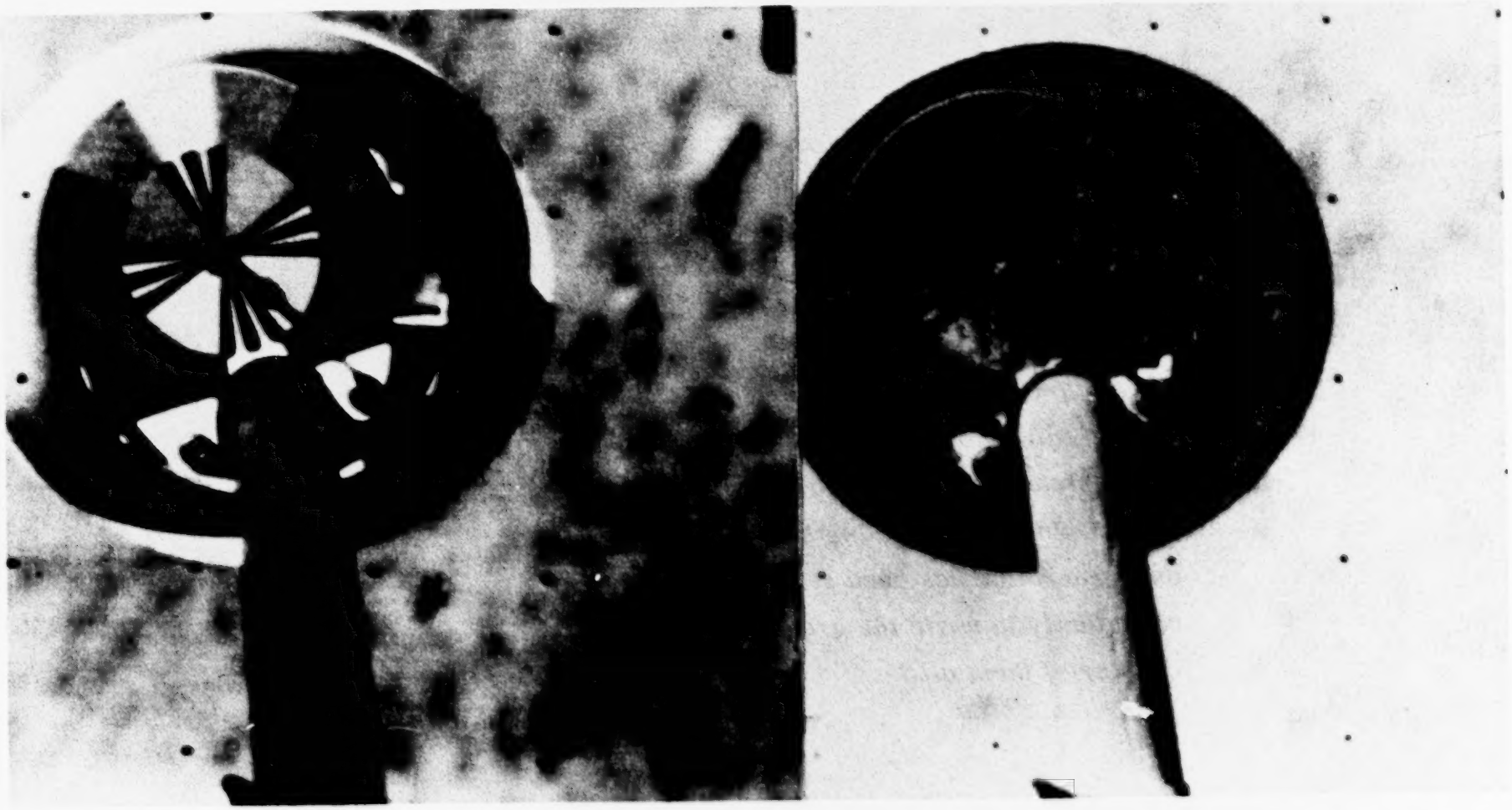
MASSACHUSETTS DEPARTMENT OF EDUCATION
IN COOPERATION WITH
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
JANUARY, 1968



This wind tunnel model of one general approach to a hypersonic (4,000 mph) transport design has undergone tests at the National Aeronautics and Space Administration's Ames Research Center. The stainless steel model has undergone tests at speeds of 500 to 7,000 mph and was simplified for study of basic aero-dynamics. A hypersonic transport probably will require 20 to 25 years to develop and many of the technologies needed are still in their infancy.

"The story of Man's advancement, throughout history, has been the story of his victories over the forces of nature. In that continuing story, our own generation has been given the opportunity to write the grandest chapter of them all."

President Lyndon B. Johnson
September 27, 1966



Lunar material blasted from the Moon's surface by Surveyor VI's rocket engines early on November 17, 1967 nearly eclipsed the photo calibration chart mounted at end of one of the spacecraft's antenna booms. Picture at right was taken shortly after 3:00 a.m., PST, November 17, 1967, less than an hour after Surveyor was commanded to launch itself off the lunar surface and move to a new site a few yards away. Photo at left was transmitted to Earth on November 16, 1967 before the three engines were fired.

Foreword

Massachusetts Department of Education

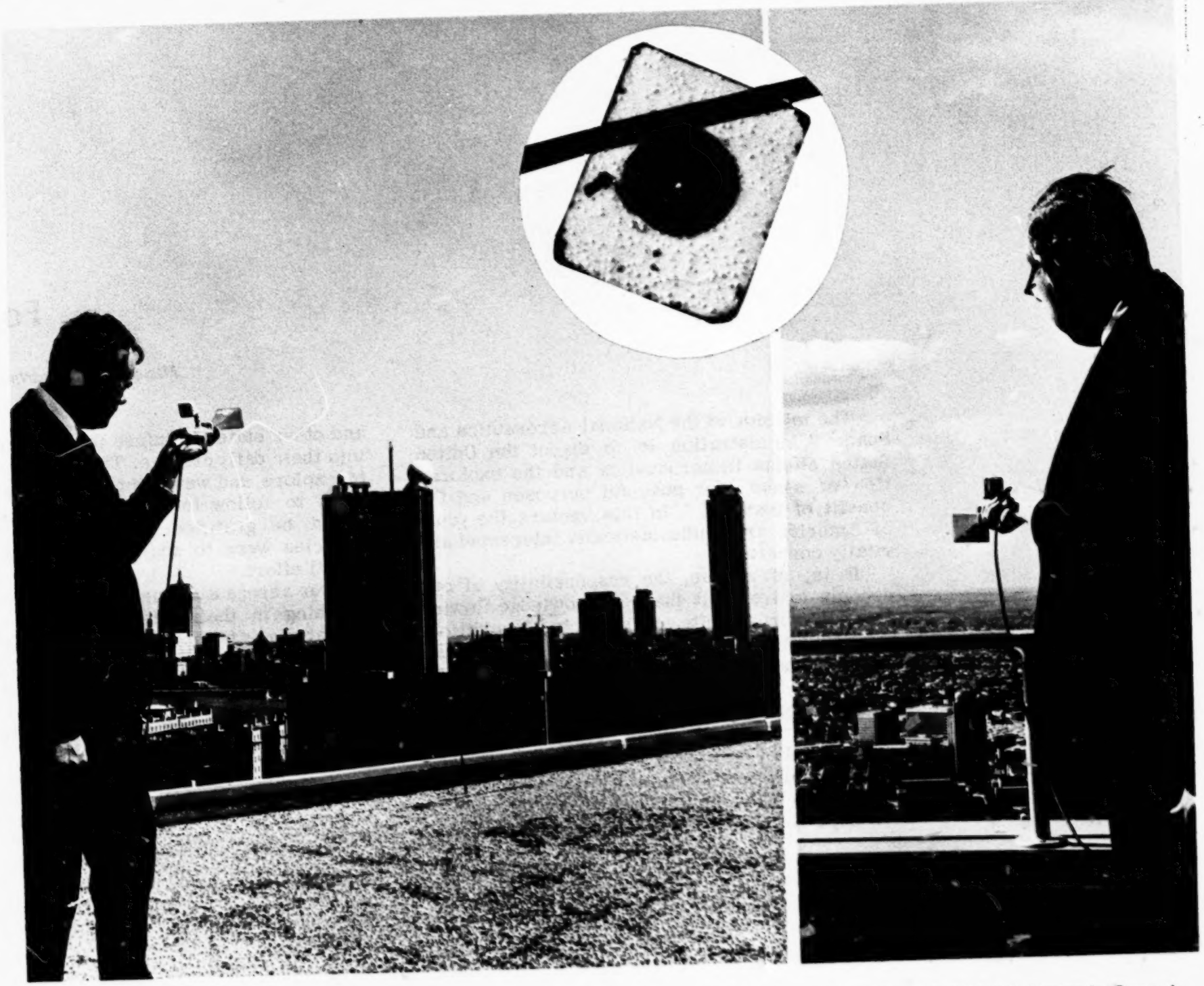
The mission of the National Aeronautics and Space Administration is to direct the United States efforts in aeronautics and the exploration of space "for peaceful purposes and the benefit of mankind." In this venture the youth of America are enthusiastically interested and vitally concerned.

It is, of course, the responsibility of our schools to transmit the new knowledge flowing from this program to our students. In addition, their excitement and interest in this unique national research effort should be used to motivate our teaching in every curriculum area.

This aerospace resource guide is the result of a unique joining of forces. The Massachusetts Department of Education and the National Aeronautics and Space Administration have worked together to develop this guide as a pilot project. We hope that it will encourage leaders in this and other states to infuse this exciting material into their daily classes. There are many avenues to explore and we hope teachers will be stimulated to follow the leads here suggested. We would be gratified also if other educational agencies were to adapt and improve upon this initial effort.

Our aeronautical and space programs are far reaching in their effect upon our world. The educational "fallout" from such a program has significant implications for our schools and for all of our children. This aerospace resource guide should be of help in the vital task of drawing teaching aids from this great potential.

Owen B. Kiernan
Commissioner of Education
Commonwealth of Massachusetts



Music from hand-held unit is beamed from the roof of NASA's Electronics Research Center (left), Cambridge, Mass., to the roof of the Prudential tower (slender tower) in Boston, and received, (right), by similar unit in a test during August, 1967 of a tiny electronic device which promises better radio communications between space vehicles. The device, shown, (insert) compared to a human hair, produces "hot" electrons which generate a microwave signal. Building at left with sphere on top is the Earth Sciences Building of the Massachusetts Institute of Technology.

Foreword

National Aeronautics and Space Administration

The National Aeronautics and Space Administration has, in the nine years of its existence, conducted a modest program in elementary and secondary education, with its primary focus on teacher needs. We have attempted to make available to teachers the results of NASA's research and development efforts in aeronautics and space. Our curriculum "enrichment" materials have been developed on a multi-media basis. Our publications, fact sheets, films, film strips, slides and charts are designed to help translate readily the new and exciting scientific and technical knowledge resulting from investigations of air and space.

The National Aeronautics and Space Administration is pleased to join with the State Department of Education of the Commonwealth of Massachusetts in developing and distributing this teacher's guide. It is intended, not as a new curriculum, but as a resource to serve teachers at all grade levels and in all subject-matter areas. It represents a compilation of space-related information to parallel and reinforce the topics and concepts normally taught.

We in NASA hope that this guide will be of interest and value to the teachers for whom it was prepared, and a source of expanded knowledge, motivation and inspiration to the students it may affect.

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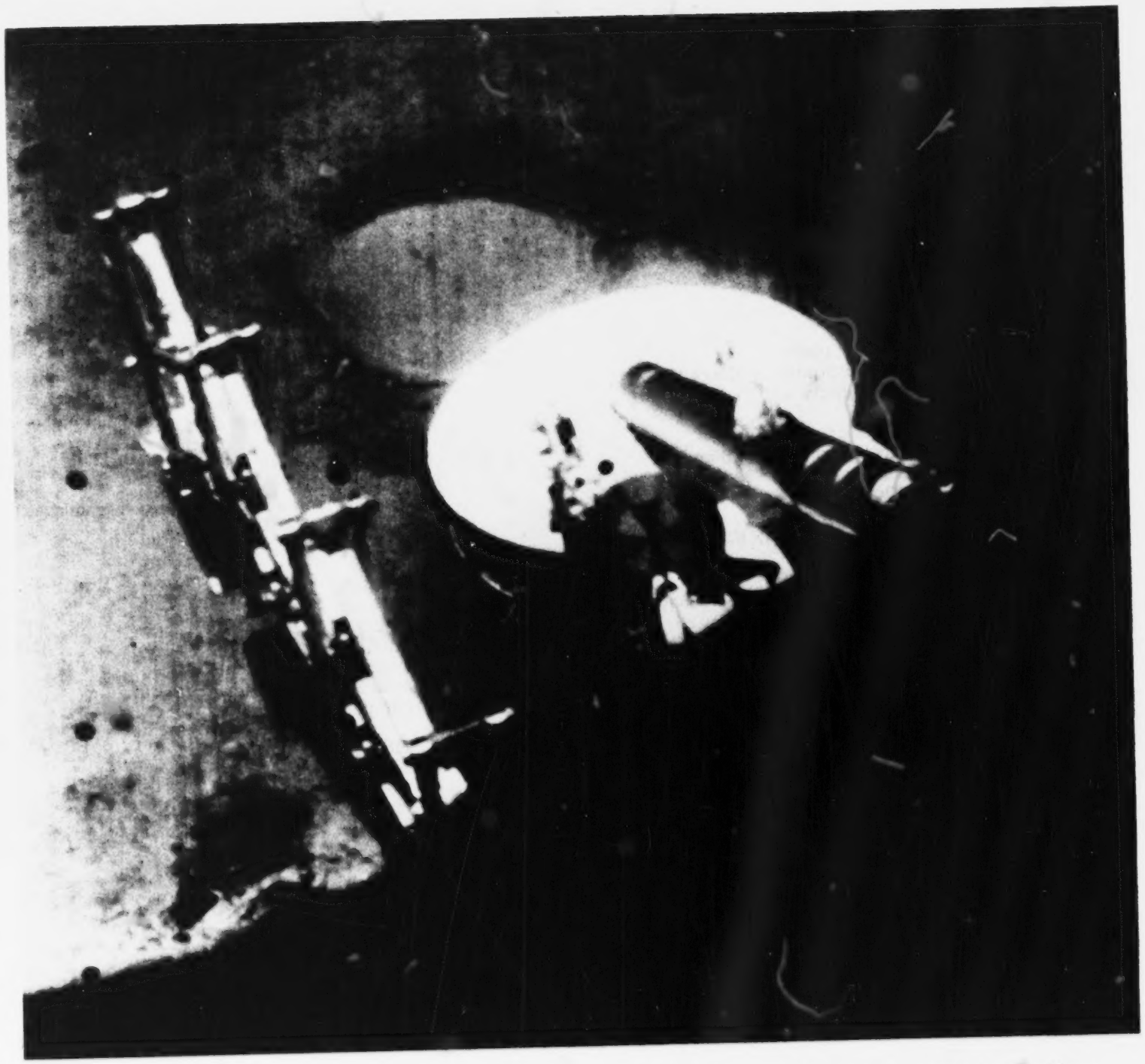

Surveyor III's surface sampler, its scoop containing about two cubic inches of lunar material, is approaching the spacecraft's footpad #2 to deposit the soil on the white surface. In order to determine correct extension for positioning the scoop over the foot, the sampler was commanded to make the surface impression seen at bottom left. Distance from the positioning mark to nearest edge of foot is nine to ten inches. Material in scoop was picked up near trench (out of view to the left) several feet away. Circular impression above foot is the imprint of the foot made as Surveyor landed on April 19, 1967. This photo was taken by the spacecraft's television camera at 3:42 a.m. PST, April 26.

AEROSPACE CURRICULUM RESOURCE GUIDE

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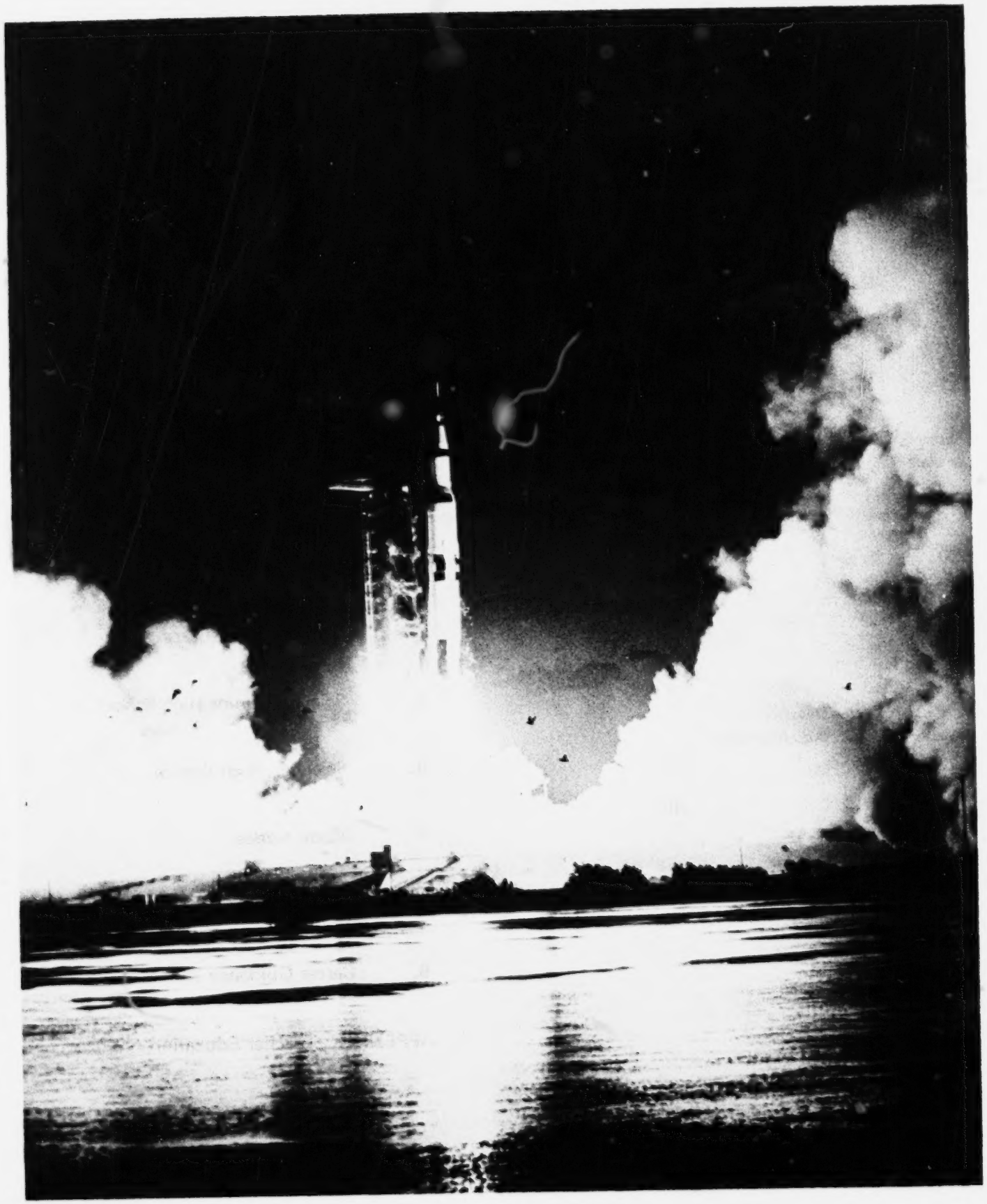

The National Aeronautics and Space Administration launched the first flight test of the Apollo/Saturn V space vehicle at 7:00 a.m., EST, November 9, 1967 from Complex 39A, Kennedy Space Center, Fla. At lift off the 363-foot launch vehicle weighed 6,220,025 pounds. The first-stage engines produced 7,500,000 pounds of thrust and burned 15 tons of fuel per second. The Apollo 4 flight plan called for the Saturn V to place the Apollo spacecraft and the launch vehicle third (S-IVB) stage into a 117 statute mile circular orbit, and did so. After completing two orbits, the third stage was re-ignited to place the Apollo spacecraft into orbit and the service module propulsion system was fired to raise the spacecraft's apogee to about 11,400 miles. A second service propulsion engine firing during descent from apogee boosted the velocity to about 25,000 miles per hour. Protected by its heat shield, the command module re-entered the atmosphere, and was recovered in the Pacific Ocean about 622 miles northwest of Hawaii.

1. Language Arts

by Project Staff

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Language Arts

INTRODUCTION

We live in an atmosphere of words. They pervade our thinking, our seeing, our hearing, and our contacts with others to such a degree that it is difficult to conceive of an existence without some kind of spoken or written language.

We live in a century that has seen unprecedented advances in the development of communication media, and with the rapidly changing nature of our entire environment where facts today may be inadequate tomorrow, these advances have endowed the language arts with a new and dramatic importance. Mastery of the language arts has become imperative. Today's living requires careful observation, thoughtful reading, intelligent listening, effective speaking, creative writing, and logical thinking. As each child matures and develops in his understanding of language and literature, meaningful experiences and purposeful activities will help him to develop his ability to communicate so he may enrich his own life as well as improve the society in which he lives.

The wealth and variety of content in space exploration offers a wide range of subject matter to enrich learning activities in the language arts from kindergarten through high school; it also offers an awareness of current events to encourage accurate listening and speaking and fires the imagination toward creative thinking and writing.

The language arts program should enable the child to develop the techniques which will encourage him to have confidence in speaking and writing. To accomplish this the following objectives should be emphasized:

1. Development of listening skills;
2. Development of the habit of accurate observation;
3. Development of speaking and writing skills which make it possible to convey ideas accurately and intelligently to others and the achievement of an increasing mastery of these skills;
4. Development of both oral and written creative expression encouraging originality and variety through an increasing and everwidening vocabulary;
5. Appreciation of the beauty of the English language. A balanced program in the language arts should give equal consideration to oral and written expression in both the development of skills and creative ability.

TOPIC 1.01

Observation

LEARNING ACTIVITIES

(K-3)

1. Prepare a list of questions about an announced television program on a space event and have the children report on the aspect that most interested them.
2. Show the film "Before Saturn." Have children discuss a prepared list of questions and then make up their own questions.
3. Study pictures of several spacecraft noting the differences and similarities of various details.
4. Make a class calendar for a particular month and record facts about the moon: shape, color, when it can be seen in the daytime.
5. Look at photographs of the moon taken through a telescope and discuss the patterns and formations that can be seen. Compare and discuss photographs taken by the Ranger spacecraft.

Walk in Space

(4-6)

1. Bring newspapers to class and show how many different kinds of information on space can be found.
2. Show the film "Suited for Space" and have students discuss what they learned about the history of space suits.
3. Observe and record the weather each day for a two-month period; have the class note and discuss cloud formations on cloudy and sunny days.
4. Collect different kinds of maps for a wall display. Discuss the kinds used for various purposes and what kind would be needed for a flight to the moon.

REINFORCEMENT

(K-3)

1. After watching a television program on a space event, have the children watch one on an imaginative space theme and compare the two.
2. Show photographs of pairs of related spacecraft, i.e., TIROS and NIMBUS, Ranger and Surveyor, Mercury and Gemini, OSO and OGO. Let the children discover the similarities as well as differences and the reasons for them.
3. On a large map of the moon locate with colored pins the areas man has photographed; place photographs and related material around the border and connect to location with string or line.
4. Plan a bulletin board on airplanes. Include types from the earliest models to the SST and V/STOL.

(4-6)

1. A Current Events Bulletin Board might be expanded and devoted to topics such as "Recent Social and Economic Developments Resulting from Space Exploration," "Space Exploration Projects in Other Countries," or "The X-15 Program."
2. Collect pictures of means of transportation or vehicles used in exploration from the horse to space capsules; choose pictures that also show how man had to adapt to different conditions, i.e., clothing, weather.
3. Look at pictures of the constellations; note their shapes and compare with various pictorial representations.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

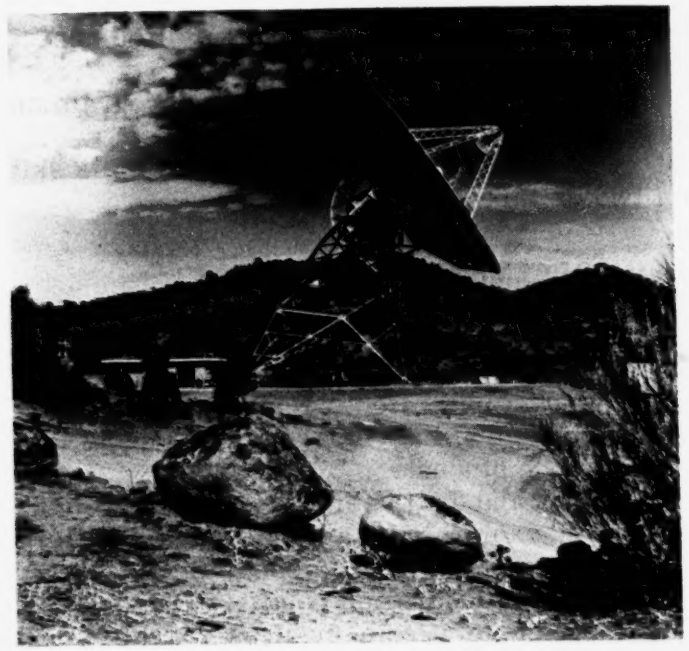
(K-3)

EP-6	Space, the New Frontier
NF-9	Manned Space Flight (Mercury-Gemini)
NF-13	OGO
NF-21	V/Stol
NF-23	Manned Space Flight: Apollo
NF-29	OSO
NASA Film:	"Before Saturn"

(4-6)

EP-6	Space, the New Frontier
EP-25	Space Exploration: Why and How
EP-42	The Planetarium
NF-8	Launch Vehicles
NF-23	Manned Space Flight (Apollo)
NASA Film:	"Suited For Space"

Tracking Antenna



TOPIC 1.02

Listening

LEARNING ACTIVITIES

(K-3)

1. After listening to an assembly program on space exploration, such as the NASA Spacemobile, have each student discuss the part he liked best.
2. Show the film "Manned Space Flight 1967" and have the children listen for answers to a prepared list of questions.
3. Read a poem about airplanes, the stars, or the moon; have the children listen for and discuss sound words, rhyming words, and words which tell pictures.

(4-6)

1. Invite a speaker to discuss modern communications; have the students illustrate at least three kinds of communication used in their homes, industry, transportation, and space projects.
2. Have the class listen to a series of weather reports and note how they are presented.
3. Show the film "The John Glenn Story." Afterwards have the children compare Columbus and Glenn and their respective places in the history of space exploration.

REINFORCEMENT

(K-3)

1. Invite a pilot to talk about his work as a "helper" in the field of transportation. Plan a follow-up project based upon the talk, such as making a picture dictionary of new vocabulary words, or making a movie about how the airplane was developed, or how the SST or V/STOL will change transportation.

2. Tell about the latest launch at Cape Kennedy; have the students form committees to report on the various phases, i.e., the spacecraft, its use, the launch vehicle, the countdown, the personnel, recovery or landing, etc.

(4-6)

1. Using a tape recorder, have students record some facts they have learned about communications. After a playback, have them explain the value of the recorder and discuss its contribution to the field of communication.
2. Tell the class about the NASA research centers in the United States or the tracking stations around the world; then read stories about the areas where these are built. Provide opportunities for the children to discuss these places in class--a report on a visit, geographic location, or a journey traced on a map--then answer questions from other members of the class.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

(K-3)

EP-6	Space, the New Frontier
EP-36	Introducing Children to Space
NF-8	Launch Vehicles
NF-21	V/Stol Aircraft
NASA Film:	"Manned Space Flight, 1967"

(4-6)

RP-6	Space, the New Frontier
EP-22	This Is NASA
EP-27	Meteorological Satellites and Sounding Rockets
EP-36	Introducing Children to Space
EP-40	Communications Satellites
NASA Film:	"The John Glenn Story"
NASA Film:	"The Four Days of Gemini 4"

TOPIC 1.03

Speaking

LEARNING ACTIVITIES

(K-3)

1. After a field trip to an airport, have the students form committees to report on various aspects of the trip.
2. Show pictures of people who work in air transportation and have the students give reports on their jobs.
3. When each student has read a book or story about space, have him give a report to the class.
4. Devote a "Show and Tell" period to the contribution of our astronauts.

(4-6)

1. After listening to a guest speaker or taking a field trip to a planetarium have the students form committees and each committee report on three facts learned.
2. Plan and present an assembly program on space exploration.
3. Dramatize a space trip with a simple skit of two or three characters.

REINFORCEMENT

(K-3)

1. Sharing experiences, in addition to telling about a book or story, may include personal experiences; news items; television, radio, and film shows; and individual space projects that interest the students.
2. "Show and Tell" periods may include many facets of exploration: a trip to an art gallery might offer a painting, piece of sculpture, or ancient vase decoration related to space; pictures of single items, such as a space suit, can serve as subjects; and new books, models, and original art works can provide interesting objects.
3. Learning about the theatre also offers an opportunity to use a variety of space subjects: dramatize a balloon, an airplane, and a space flight; dramatize a day in the life of a pilot, an imaginary trip to the moon, or, using puppets, sending an animal into space; select a poem appropriate for choral reading.

(4-6)

1. Plan a radio program based upon current space news, interviews with famous space scientists, a new invention, or a broadcast from a tracking station.
2. Oral reports may cover broad subject areas or be limited to a narrow field of interest: the history of balloon travel; orbiting observatory satellites; the suborbital Mercury flights; the different kinds of launch vehicles; the problems of man in space; scientists who contributed to the development of rocketry; an astronomer's work.
3. Begin a series of vocabulary lists to discover how words may be formed from root words, to increase knowledge of aerospace terms, and to learn about compound words. Climax the work study with a spelling contest using the vocabulary lists.
4. Many space subjects lend themselves to dramatization. Choose one to develop as a one-act play: an interplanetary trip, a passage from mythology, a flight in the X-15, episodes in the development of the airplane, an imaginary trip to the moon.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

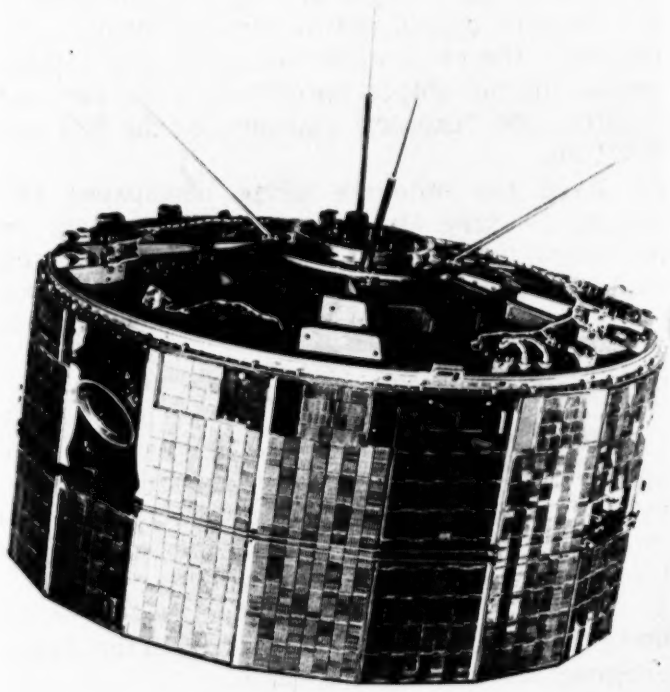
(K-3)

EP-6 Space, the New Frontier
EP-34 NASA Astronauts
EP-35 Aerospace Bibliography
EP-36 Introducing Children to Space
EP-42 The Planetarium
Complete NASA FACTS

(4-6)

EP-6 Space, the New Frontier
EP-22 This Is NASA
EP-25 Space Exploration: Why and How
EP-27 Meteorological Satellites and Sounding Rockets
EP-34 NASA Astronauts
EP-36 Introducing Children to Space
EP-40 Communications Satellites
EP-42 The Planetarium
Complete NASA FACTS

Tiros VIII



TOPIC 1.04

Reading

LEARNING ACTIVITIES

(K-3)

1. Read chart stories about work at an airport, Project Gemini, or weather and meteorological satellites.
2. Develop a picture dictionary of aerospace terms.
3. Encourage independent reading by having the children report on legends and myths connected with flight.

(4-6)

1. Provide a library corner with a variety of books on aerospace subjects that include history, biography, autobiography, the classics, science fiction, poetry, and plays.
2. Select a topic such as communications satellites and have the students read a news story, a feature article, and an interview connected with the subject and discuss them in class.
3. Help the students to differentiate between fact and fiction by having them read science fiction books and compare them with factual materials from authentic scientific sources.

REINFORCEMENT

(K-3)

1. Develop the library corner with many types of books on one space subject, such as flight: its history, early myths, biography of the Wright Brothers, the X-15, stories about the astronauts, an imaginative flight to the moon. Continue with a variety of subjects.
2. Establish a Reading Day or Poetry Day for original class stories and poems.
3. Have the students select and dramatize passages from storybooks about lunar and interplanetary flight.
4. Show the filmstrip "Project Apollo: Manned Flight to the Moon," have the children find a storybook about a lunar flight, and then compare the two.

(4-6)

1. Encourage the children to keep informed about current events by reading articles on space exploration in magazines as well as newspapers; have them bring articles and pictures about the latest launching to class for a bulletin board display.
2. When the students have had an opportunity to compare different styles of writing, have them select one subject to read about, e.g., a planet, a satellite, a constellation, to see how many kinds of literature they can find on it, what type of material is included in each, and discuss the objective of the several authors.
3. Have the children collect materials about the practical benefits of space exploration and then discuss the points of view expressed by various sources.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

(K-3)

EP-6 Space, the New Frontier
EP-22 This Is NASA
EP-27 Meteorological Satellites and Sounding Rockets
EP-34 NASA Astronauts
EP-36 Introducing Children to Space
EP-40 Communications Satellites
EP-42 The Planetarium
EP-45 Fifty Years of Aeronautical Research
NF-8 Launch Vehicles
NF-9 Manned Space Flight (Mercury-Gemini)
NF-23 Manned Space Flight (Apollo)
NF-30 Gemini Pictorial
NASA Filmstrip:
"Project Apollo--Manned Flight to the Moon"

Rocket-Powered X-15 Research Plane

(4-6)

EP-6	Space, the New Frontier
EP-22	This is NASA
EP-25	Space Exploration: Why and How
EP-27	Meteorological Satellites and Sounding Rockets
EP-34	NASA Astronauts
EP-36	Introducing Children to Space
EP-39	Report From Mars
EP-40	Communications Satellites
EP-42	The Planetarium

Complete NASA FACTS

TOPIC 1.05

Writing

LEARNING ACTIVITIES

(K-3)

1. Prepare word lists using the names of planets or space projects and have the children use each word in a sentence.
2. Write captions for scrapbooks on the earth, solar system, moon, constellations, or applications satellites.
3. Keep a class diary of space-related activities recording field trips, visitors, special programs, club participation.
4. Give the children opportunities to learn about writing letters and addressing envelopes: a thank-you letter to the contact person at the airport after a field trip; a letter to an absent classmate describing the trip; a letter to a friend describing studies of space; and an invitation to parents to see a class space program.
5. Provide opportunities for the children to write imaginative paragraphs about space: How the Satellites got their names; how the earth looks from a space capsule; the landscape of the moon or planets; or pictures the constellations make.
6. List several ideas for original stories or poems: What it is like to ride in a spacecraft; A trip along the Milky Way; How it will feel to land on the moon; How the wind helps us; A day at a tracking station; "The Man in the Moon."
7. Give practice in punctuation, grammar, capitalization, and spelling by having the students proofread their compositions with specific rules in mind and checking for accuracy.

(4-6)

1. Prepare functional spelling lists using map and globe terms, names of planets, names of space projects, or other space-related words illustrating syllabification and accent marks.
2. Have the students plan a class book on their space studies; let one committee prepare an outline for each chapter, another write the material, another provide the captions, and another the table of contents and indexes.
3. Have students write brief biographies of the men who have contributed to the development of air transportation, pioneers of science, or famous navigators.
4. Read an article about a satellite to the class; have the children take notes, organize the information into an outline, and then write a brief summary.
5. Give the students opportunities for creative writing: a journal account of the first weeks establishing a new colony on the moon; poems about rockets; an imaginary log for an Apollo earth-orbiting flight; a day in a space station.
6. Provide opportunities for expository writing: have the students write short compositions explaining the objectives of the observatory satellites, the tracking stations, or the SST and V/STOL.
7. Have the students write newspaper articles: a story about a recent launching, an interview with a civic personality about space exploration, a review of a scientific book, or a feature article on the benefits of space research.

REINFORCEMENT

(K-3)

1. Word lists can be expanded with each new space study to encourage correct spelling, syllabification, and definition. Word games can introduce compound words and the use of prefixes and roots to form new words.
2. Give the children opportunities to write their own chart stories on any part of the space program which interests them.
3. Have the children write riddles about airplanes, rockets, meteorological satellites, or

geographical features they have studied which resemble views of the moon. Make a booklet of the riddles.

4. Provide a variety of pictures -- a space suit, aircraft, the Andromeda galaxy -- for the children to use as subjects for descriptive paragraphs.

5. The subject for friendly letters may center upon holiday celebrations: a letter to a Martian describing Christmas preparations, Fourth of July festivities, or inviting him to a Thanksgiving dinner.

6. Creative writing, whether imaginative paragraphs or original stories and poems may continue with projects such as having the student pretend he is the "Man in the Moon" and, looking at the earth, describing what he sees; giving an "eyewitness" account of a first trip in space; what people on another planet might be like; or how transportation may change in the future.

(4-6)

1. Prepare word lists of various aerospace terms and have the students check the derivation of each in the dictionary. Follow with word lists relating to specific programs, e.g., communications, astronomy, weather, using them to increase understanding of word formation.

2. Provide a variety of writing projects to give practice in outlining: research reports on tracking, famous scientists, history of aviation, or the solar system; book reports; oral reports on a current space event; or written compositions on mythological names and space projects.

3. Note a series of newspaper and magazine articles for the students to read on space benefits--how solar energy may lead to new applications in heating and lighting homes, medical advances made by space research, new materials adopted by industry--and have them write short themes to give practice in organizing and summarizing ideas.

Model of Surveyor Spacecraft

4. Have the students write autobiographical compositions, personal experiences related to aerospace, e.g., a trip to a NASA installation or pertinent industry, a ride in an airplane, a science project, and reactions to a radio or television program.

5. Encourage practice in creative writing by suggesting several ideas: space ships of the future; a travel folder for one of the planets; an experience in a hurricane or tornado; conversations between a space ship and ground control or with a travel agent to plan an interplanetary trip; a science fiction narrative in autobiographical form.

6. Have the students devote an entire issue of the school newspaper to space.

7. Continue to give practice in grammar, punctuation, and spelling by having the students proofread their compositions.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

(K-3)

EP-6	Space, the New Frontier
EP-27	Meteorological Satellites and Sounding Rockets
EP-34	NASA Astronauts
EP-36	Introducing Children to Space
EP-37	Project Gemini
EP-39	Report from Mars
EP-40	Communications Satellites
EP-42	The Planetarium
EP-45	Fifty Years of Aeronautical Research

Complete NASA FACTS

(4-6)

EP-6	Space, the New Frontier
EP-25	Space Exploration: Why and How
EP-27	Meteorological Satellites and Sounding Rockets
EP-34	NASA Astronauts
EP-36	Introducing Children to Space
EP-37	Project Gemini
EP-39	Report from Mars
EP-40	Communications Satellites
EP-42	The Planetarium

Complete NASA FACTS

NASA Filmstrip:
"Eyewitness to Space"

TOPIC 1.06

Listening

LEARNING ACTIVITIES

(7-9)

1. Have small committees prepare brief oral reports on sound; after giving the reports, select a number of students not on the committees to repeat the basic facts presented.
2. Show the film "The First Soft Step" and have the students listen for answers to prepared questions.
3. Have the students make a list of the kinds of work in space activities that require good listening and write an explanatory paragraph on each telling why listening skill is required.
4. During a one or two-week period have the students listen to radio, television, and public speakers for descriptive words and phrases that are particularly pertinent to the Space Age.

REINFORCEMENT

1. The reports on sound may be followed with a variety of oral reports on subjects such as "The Development of Electronics and Sound", "Communications Satellites," or "Sounds of the Space Age."
2. Ask the students to watch one commercial and one educational television program on space and compare similarities and differences. A class committee might keep a bulletin board of coming space-related radio and TV programs for listening projects.
3. Have the students develop their reports on space jobs that need listening skills with descriptive paragraphs on situations where a person hears many sounds but must listen to one, i.e., how an astronaut might need this skill.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space, the New Frontier
EP-22	This Is NASA
EP-32	Learning about Space Careers
EP-33	Seven Steps to a Career in Space Science and Technology
EP-34	NASA Astronauts
EP-35	Aerospace Bibliography
EP-40	Communications Satellites
NASA Film:	"The First Soft Step"

Saturn V – First Trip to Pad

TOPIC 1.07

Speaking

LEARNING ACTIVITIES

(7-9)

1. Plan a round table discussion on a broad aspect of the space program: benefits, history, applications satellites, manned space flight, or the future of air transportation.
2. Have each student select a map, a graph, or a cartoon related to space exploration and give a brief talk about his choice.
3. For individual talks have the students list occupations in which speech ability is a main requirement and how these apply to the aerospace industry.
4. Select a number of students to interview several teachers for their views on the space program and how it relates to their subjects, e.g., science, social studies, art, music.

REINFORCEMENT

1. Round table discussions may develop from many assignments: several students reading the same science fiction book, a film such as "Before Saturn," or a selected television program.
2. Cartoons are a lively source of oral presentations. Have the students collect a series commenting on one aspect of the space program or several concerned with various views of space exploration; each student should mount his pictures and discuss their effectiveness in a talk to the class.
3. Practice pronunciation of aerospace words added to the class vocabulary lists.
4. Individual talks might include the following subjects: characteristics that make men great, using space heroes; "I think I should like to work as a space scientist"; a favorite character

in science fiction; a real life experience involving a space activity; a report on a concept in science or a science experience tracing the logical development or procedures that led to the final result.

5. Interviews might be expanded to the world outside the school -- the author of a space book, an elderly person who knew life before radios and airplanes, a civic leader, someone employed in the aerospace industry.

REFERENCES and RESOURCES

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EP-25	Space Exploration: Why and How
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EP-35	Aerospace Bibliography
EP-40	Communications Satellites
EP-45	Fifty Years of Aeronautical Research
NF-9	Manned Space Flight (Mercury-Gemini)
NF-23	Manned Space Flight (Apollo)
NASA Film:	"Before Saturn"

TOPIC 1.08

Reading

LEARNING ACTIVITIES

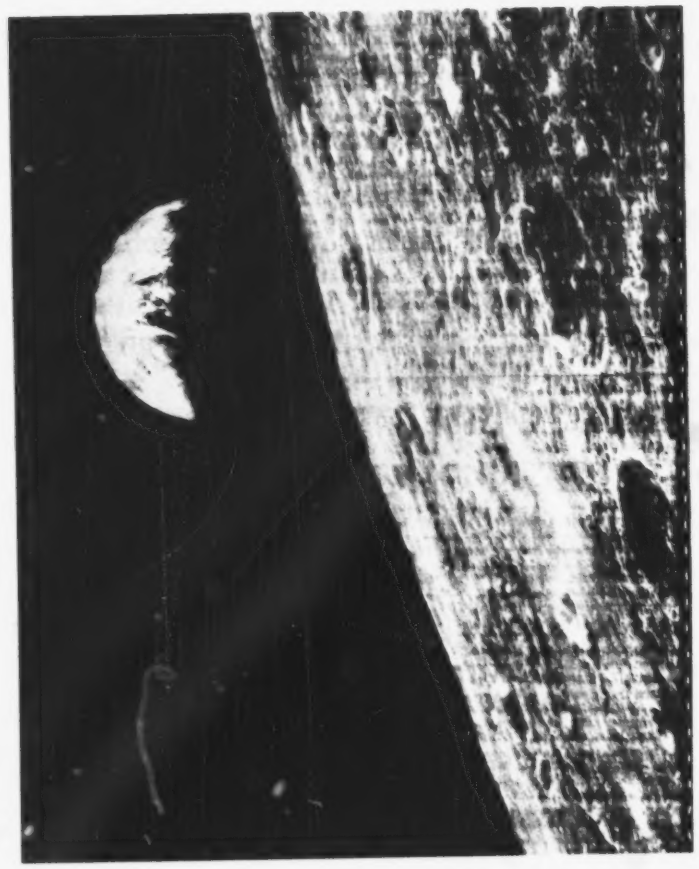
(7-9)

1. Prepare a list of questions about a variety of space projects; have the students decide in which kind of reference book they will find the answers, look them up, and report to the class.
2. List several air and space books that sound interesting. Have the students check the school library card catalogue to see if they are available; if not, have them select another book by the same author for a report.
3. Continue their reading assignments with comparison studies: two essays on the benefits of space exploration by different authors, two science fiction stories, two poems on the stars, two articles about Dr. Robert H. Goddard, or two historical surveys of exploration.
4. Ask the students to watch for vivid descriptive words in all their reading about the space program.
5. Have the students select well-written paragraphs or short poems related to aviation to read aloud for class discussion.

REINFORCEMENT

1. Have the students keep a classroom card catalogue for outside reading assignments on space subjects. It may be a subject catalogue at first, then add author and/or title sections.
2. Book report assignments can be expanded with original interpretations; e.g., a student might cast a motion picture based upon a science fiction novel or present an imaginative section on what the future might bring; the report on a nonfiction book on aviation could be presented in the form of an "argument" with two students; a history of rocketry might inspire a dialogue also, while biographies lend themselves to discussions of what current activities and accomplishments can be traced to the thought or work of the individual.
3. Follow an interest in paragraphs with well-defined topic sentences with a listing of those which are not clearly written, use cliches, or contain grammatical errors.
4. Vocabulary lists of new words give practice in dictionary skills; have the students list the

First Earth Photo from Lunar Orbiter I



source and history of the words as well as definition. A second list of misspelled words found in ads, the school paper, magazines, signs, or circulars will enhance the students' awareness of correct spelling.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space, the New Frontier
EP-22	This Is NASA
EP-25	Space Exploration: Why and How
EP-27	Meteorological Satellites and Sounding Rockets
EP-34	NASA Astronauts
EP-37	Project Gemini
EP-40	Communications Satellites

Complete NASA FACTS

TOPIC 1.09

Writing

LEARNING ACTIVITIES

(7-9)

1. List articles about several subjects -- the Wright Brothers, interplanetary probes, tracking, communication in the 19th and 20th centuries -- and have the students read one, take notes, and prepare both a topic and a sentence outline.
2. Give the students opportunities to practice word usage and sentence structure; ask them to bring to class ten new words learned in their reading about space and to write a sentence using each. Follow with simple sentences describing a gantry, the crowd at a launching, Echo crossing the sky, a comet, the splashdown ending a manned flight.
3. Give the students opportunities to write informative articles and essays on space projects, e.g., scientific satellites, international space programs, mythology and space names, women in the space program, and supersonic travel.
4. Give students an opportunity to write different kinds of reports: on books dealing with space topics; a comparison of two biographical accounts of an astronaut, scientist, or engineer; a space exhibit; or a field trip.
5. Have the students practice letter-writing with an inquiry about a class subscription to a science magazine, an order for spacecraft models to a hobby company, an announcement of a science fair to a newspaper, or a request for information to an aerospace industry.
6. Provide opportunities for writing creative prose: a science fiction short story; a letter to a friend on earth describing a typical day in 2000 A.D. on the moon; an article for the Chamber of Commerce of a planetary city describing the advantages of living there in order to attract new residents; a strange experience or an exciting dream inspired by visions of space.

REINFORCEMENT

1. Additional practice in word usage and sentence structure can be given with follow-up exercises such as rewriting the sentences using different words which express the same meaning, inverting the sentences when possible, or expanding simple sentences to compound sentences.
2. Based upon the aerospace material included in their outlines, paragraphs, articles, and reports, have the students make up a title for five different subjects.
3. After completing a unit of study on space, have the students prepare a class newspaper with the material adapted to news stories, editorials, an announcement, a column, and feature articles.
4. Informative essay assignments might be followed with persuasive essays on subjects such as "what piece of space research in the U.S. will interest a foreign visitor," "Women should be more active in the space program," "Supersonic speeds in air travel," and "International space programs foster understanding."
5. Reports written in the first person might explore topics such as education needed for a specific space-age career, an impression of newspaper comics set "in space," reaction to the NASA film "Trial Balance," or a comparison of two scientific magazines.
6. Creative prose writing may also include novel points of view, i.e., a telegraph wire, the control panel on a manned spacecraft, radio waves, a constellation; humorous writing about personal experiences such as a first airplane ride; and descriptions of sensations such as the loneliness of space, the darkness of space, the heat of a star.

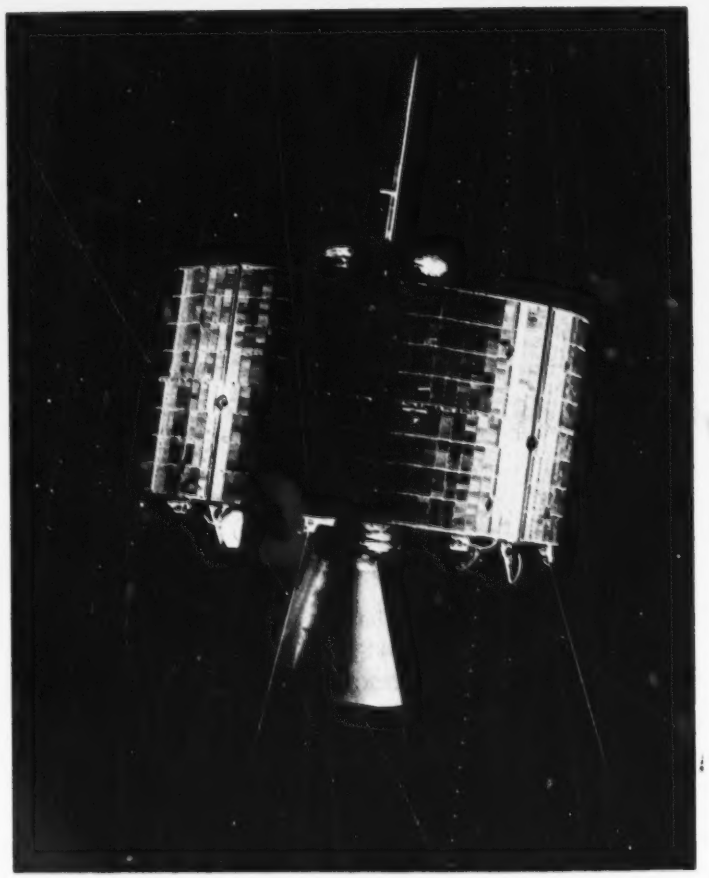
REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space, the New Frontier
EP-22	This Is NASA
EP-25	Space Exploration: Why and How
EP-27	Meteorological Satellites and Sounding Rockets
EP-32	Learning About Space Careers
EP-33	Seven Steps to a Career in Space Science and Technology
EP-34	NASA Astronauts
EP-38	Report from Mars
EP-40	Communications Satellites

Complete NASA FACTS
NASA Film: "Trial Balance"

Syncom Satellite



TOPIC 1.10

Listening

LEARNING ACTIVITIES

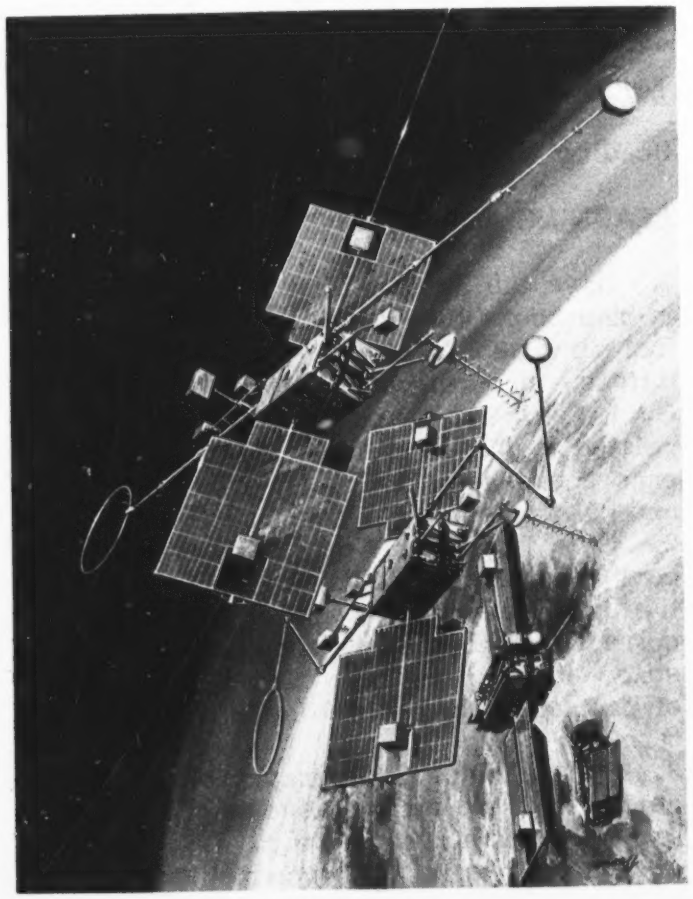
(10-12)

1. Select committees to prepare an oral report on one purpose of listening, such as information, inspiration, and pleasure, after viewing the NASA film "The Mastery of Space."
2. Show the NASA film "Living in Space" and have the students take notes to prepare a two-minute summary at the conclusion.
3. During a two-week period have the students listen to news television programs for unfamiliar words used in reporting space events.
4. Have the students list industries and professions in which sound is important and has been affected by space-age technology.

REINFORCEMENT

1. Following committee reports on the purposes of listening, have the students prepare individual reports on a NASA film of their choice listing one or more reasons for wanting to see it.
2. Show the NASA film "Returns from Space" and have the students listen for subjects which could be used for research papers.
3. Each week or month a committee might collect new concrete or abstract words pertinent to the Space Age which are used in radio and television programs. The lists can serve as ideas for topic sentences in writing assignments, for spelling tests, and for practice in dictionary skills.
4. After listing industries and professions in which sound is important have each student

Orbiting Geophysical Observatory



select one for an oral or written report, e.g., "The effect space exploration has had on music," "... on aviation," etc.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-35	Aerospace Bibliography
EP-40	Communications Satellites
NF-8	Launch Vehicles
NF-21	V/Stol Aircraft
NASA Film:	"The Mastery of Space"
NASA Film:	"Living in Space"
NASA Film:	"Returns from Space"

TOPIC 1.11

Speaking

LEARNING ACTIVITIES

(10-12)

1. Plan a panel or round table discussion on the contributions of scientists and engineers to space exploration, weather forecasting, astronaut training, or the role of women in the space program.
2. Start a class file of magazines. Have each student present a two-minute talk on a favorite news or scientific magazine or a comparison between two periodicals.
3. During a major space event have the students follow the development of news coverage on television and radio, in newspapers and magazines, and prepare brief commentaries.
4. Give the students opportunities to present book reports on aviation, space, and science in different fashions, i.e., humorous, personal impressions, comparing drama and fiction, or discussion groups.

REINFORCEMENT

1. Keep a box in class for students' ideas for round table, panel, or debate topics suggested by their aerospace studies.
2. Oral reading may include short paragraphs on space themes found in newspapers and magazines. Ask each student to introduce his selection with his reasons for choosing it.
3. After watching television discussion programs such as "Meet the Press" and "Face the Nation," have the class present a similar program on a space theme: The Future of Transportation, International Cooperation in Space, Why Education is Important to the Space Program.
4. Follow book reports with students' selections of paragraphs to read aloud that express a specific mood or feeling.
5. Class dramatizations might include a "sidewalk interview" after a space activity is

covered on TV, an airport control tower, astronauts in space flight and a tracking station, or an imaginary interplanetary flight.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

EP-6 Space, the New Frontier
EP-22 This Is NASA
EP-25 Space Exploration: Why and How
EP-27 Meteorological Satellites and Sounding Rockets
EP-33 Seven Steps to a Career in Space Science and Technology
EP-34 NASA Astronauts
EP-35 Aerospace Bibliography
EP-40 Communications Satellites
EP-45 Fifty Years of Aeronautical Research
Complete NASA FACTS

EP-6 Space, the New Frontier
EP-25 Space Exploration: Why and How
Complete NASA FACTS

TOPIC 1.12

Reading

LEARNING ACTIVITIES

(10-12)

1. Have the students list the variety of reference books they have in the school library, including publishers' indexes, books of quotations, unabridged dictionaries, Readers' Guide, etc.; have each student select a space-related topic and then decide in which reference books he will find (1) basic information and (2) supplemental information.
2. Give the students opportunities to develop comprehensive vocabulary lists; in addition to the definition and spelling of new words acquired through reading about aeronautics and space exploration, have them find the history of each new word as well as of more familiar terms.
3. Start a class bibliography of books concerned with the various aspects of aeronautics and space exploration.
4. Book report assignments can include science fiction novels as well as space-age biographies, memoirs, history, travel, and drama.
5. Ask the students to bring to class examples of well-written paragraphs they find in newspaper and magazine articles about space events or projects.

REINFORCEMENT

1. When compiling word lists, have the students study those brought into the vocabulary by science and industry with the advent of the Air Age and the Space Age.
2. A bibliography might be compiled by each student for his own reading assignments on various aerospace subjects, e.g., history, exploration, science, and fiction.
3. Comparison reports might include space literature interpreting the writing in terms of the age in which it was written, e.g., Verne and Saint-Exupery and Azimov.
4. Throughout their reading have the students look for figures of speech, vivid descriptive words and phrases, varieties of word usage and sentence structure.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

EP-6 Space, the New Frontier
EP-25 Space Exploration: Why and How
Complete NASA FACTS

Helicopter Recovery of Astronaut

TOPIC 1.13

Writing

LEARNING ACTIVITIES

(10-12)

1. Have each student select one of the NASA FACTS series, prepare a topic and a sentence outline from it, and write a précis of it.
2. Have the students prepare a bibliography for a term paper on an aerospace subject.
3. Give the students opportunities to write explanatory cards for school programs, e.g., a science fair, library exhibit of books on aviation, etc.
4. Encourage the students to practice writing figures of speech using aerospace subjects such as clouds, lasers, the polestar, satellites, Echo, transmitters, radar, wind, airplanes.
5. Have the students write different types of expository paragraphs using air and space subjects: radar, the "why" of space exploration, the method used in a scientific experiment, travel by propeller and jet airplanes, music and electronics.
6. Suggest a number of broad subjects such as space exploration, communications, the history of flight, meteorology, recent developments in science, and have the students select a facet of one for a research paper.
7. Include air and space topics in suggestions for creative prose: a science fiction short story concerned with space travel; a one-act play about people involved in space research; a dramatic monologue on outer space; a character sketch.

REINFORCEMENT

1. Continue practice in writing one-paragraph summaries with one or more of the following when discussing space exploration: an assembly program, a sermon, magazine article, chapter in a science book, a science experiment, an editorial.
2. After the students prepare bibliographies, have them use several different items as sources for examples of footnotes.
3. Give the students opportunities to practice many kinds of explanatory writing: Have them write one topic sentence on an aerospace subject, develop it into a 100-word paragraph, and then reduce it to 50 words; have them discuss the same subject in the first person; and have each student prepare three titles for the composition.
4. After researching a subject, have each student use it to write brief essays or reports from several points of view, i.e., persuasive, informative, critical, descriptive.
5. Enliven the students' creative writing by having them adapt their space prose and poetry to the first person.

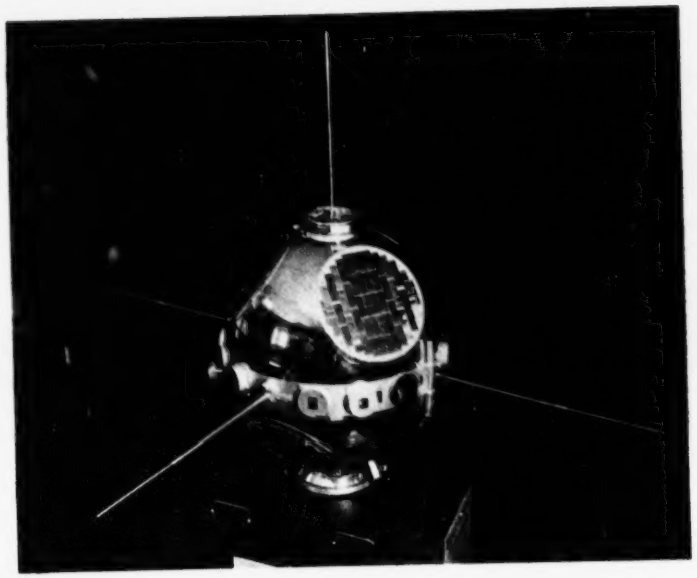
REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space, the New Frontier
EP-25	Space Exploration: Why and How
EP-27	Meteorological Satellites and Sounding Rockets
EP-28	Tracking
EP-30	Space and the ICY--A National Challenge
EP-40	Communications Satellites
EP-45	Fifty Years of Aeronautical Research

Complete NASA FACTS

Solar Explorer Satellite



The Lunar Orbiter V spacecraft trained its telephoto lens on the sunlit side of the Earth and made this first photograph of the nearly-full planet from 214,806 miles away. The time was 5:05 a.m., EDT, Aug. 8, 1967, and solar noon lay over the center of Saudi Arabia. Much of the lighted hemisphere was free of cloud cover, and the picture contains outlines of the entire east coast of Africa from the Mediterranean to the Cape of Good Hope. Features such as Italy, Greece, Turkey, the Red Sea, the Arabian Peninsula, and the Suez Canal area are visible. The subcontinent of India shines through a light covering of clouds at the center of the photograph. Near the top lies the North Polar region. When the picture was made Lunar Orbiter V was about 3,640 miles above the surface of the Moon.

2. Social Studies

by Arnold F. Lann
John P. Neal
Terrence P. O'Donnell
Mary E. Stapleton

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Social Studies

INTRODUCTION

The term Space Age is the most current designation applied to a period in Man's technological and social development history. When such a designation becomes accepted it is usually because the impact of that "age" has been universally experienced and because Man must face an entirely new set of guidelines for his thought and action.

The teaching of Social Studies is the first to feel revolutionary change in the technological or social development of mankind. This is an entirely defensible statement in view of the generally accepted viewpoint that Social Studies are primarily concerned with human relationships and the purposeful activities and institutions of mankind.

The Space Age is best typified by rapid change in almost every area of interest to the Social Studies teacher. Geographic understandings, time-space relationships, climate and weather information, knowledge about other peoples of the world, changing industrial emphasis and occupational opportunity - these are but a few of the areas of increasing importance in a world where speed of communication, transportation and technological advance makes everyone in the world a next door neighbor.

Just as the astronaut looks back at a rapidly shrinking world as he is catapulted into space - Earthbound Man must become aware of his increasing sociological proximity to the rest of the world as mankind breaks the bonds of limitations that form much of the thinking that underlies teaching today... in all subject areas.

Development of certain concepts, understandings, values, habits and skills have undergone an immediate reaction to successful space research and exploration. Among these are such concepts and understandings as:

1. The exciting implications of a new age of exploration.
2. The three dimensional world we live in and its place in the universe.
3. The extension of Man's environment through revolutionary changes in transportation and communication.
4. The social concepts and hazards created by the advances in aeronautics and space exploration.
5. The effect of space exploration upon the industrial life of a community, state, nation, and world.
6. New vocational trends and increased opportunity created by aerospace technology.
7. Effect of the technological advances upon educational requirements in all fields of specialization, technological or otherwise.
8. The problems of regulating national and international use of air and space.
9. The effects of vast and costly projects upon the world's economic resources.
10. The demands of the aerospace effort upon natural resources of the world.

Such a conceptual framework can be expanded almost without limitation. What is important about identifying such concepts is the reinforcement it affords to basic values such as:

a. The need for cooperative interdependence of people in a compact world.

b. Creativeness in seeking solutions to the challenges presented by Man's involvement in space.

c. International support of regulatory agreements made necessary by increased and expanded use of air and space.

d. An appreciation of the peaceful benefits accruing to mankind as a result of his intellectual restiveness; his new refusal to accept arbitrary limitations to his potential in space or in any other area of interest.

It is necessary to underline the disturbing difference between students of a generation ago who found stultifying security in a set of accepted limitations and today's student who is thrust into a world where limitations are disturbingly transient.

"Man can fly only so far, so fast, so high." "Man is only capable of so much knowledge." These statements of a generation ago have changed with the advent of space research and exploration. A new concept of unlimited potential for Mankind is a far more defensible reason for both teaching and learning in Social Studies as in all other subjects.

The majority of the pupils in elementary schools today will ultimately be engaged in occupations which do not now exist. Keeping pace with the "Leaping Technology" of the Space Age is our only means of insuring their progressive fitness for the future.

INTRODUCTION: PRIMARY LEVEL

During the period of early childhood education Social Studies are usually centered in the child's immediate environment. Emphasis is on living in the home, neighborhood and community.

The child's world, however, is becoming wider in scope--at an earlier age. He travels more extensively through the medium of television. He becomes more familiar with other countries and customs of other people. He identifies with and is keenly interested in the astronauts, space travel and scientific satellites. Such a keen interest is an effective motivational force during this developmental period. It is invaluable as a means to strengthen some

pertinent general objectives in the primary area. These general objectives are:

1. To acquaint the pupil within his level of maturity with the physical features of the Earth and its relationship to the Universe.
2. To understand the problems man must solve in order to provide for the necessities of life in an increasingly complicated society.
3. To help the child visualize ideas and orient himself in time and space.

"Who is to say what is impossible. The dreams of yesterday are the hopes of today and the realities of tomorrow."

Dr. Robert H. Goddard

TOPIC 2.01

Our surroundings have a direct relationship to scientific discovery. We will live differently 50 years from now because of Space Age discoveries.

LEARNING ACTIVITIES

(K-3)

1. Develop an over-all concept of the solar system. Emphasis should be placed on the idea that it is a part of a galaxy and that there are limitless galaxies. Stress the vastness of the solar system alone and the fact that man's present space accomplishments and goals deal only with (his own) solar system at the present time.
2. Learn names and elementary facts about those planets and stars that Man has identified but has not yet investigated.
3. Discuss at greater length the three about which Man has recently obtained factual scientific data: the Moon, Mars, and Venus. Discuss which planets man may visit and what advantages he might gain by doing so.
4. Using a suspended model of the solar system, flannel board cut-outs or blackboard diagram, dramatize the relatively small distance Man has been able to penetrate his own universe. This can be easily done by color keying the planets or stars we have investigated or by diagram of straight line distances using Earth as the starting point and extending to each object in the universe model or diagram. These lines should be labeled with distances in miles.
5. In cooperation with other teachers, provide a large enough student audience to justify an invitation to a resource person from the aerospace industry or government agency to talk about some aspect of the space program that is involved in identifiable social studies areas such as transportation, communication, or industry.

TOPIC 2.02

The sun influences society and industry around the world.

LEARNING ACTIVITIES

(K-3)

1. Discuss the differences in clothing, occupations, plant life and recreational activities in different areas of the world.
2. Using easily available specialized apparel such as raincoats, snowsuits, boots, earmuffs, swimsuits, umbrellas, etc., create a display that points out Man's need to adapt to the environment he lives in. In the same display, relate the problems of the child's own immediate environment with:
   A. People in other areas of the world:
      1) Arctic regions
      2) Tropics
      3) Desert
      4) Jungle
   B. Discuss reasons why the US trains its astronauts on how to survive in all of these conditions.
3. Organize a class project to create a mural showing recreational activities in the same categories. A special related project or discussion would be based upon what familiar games might be like on the Moon. Consider such factors as weak gravitational pull, lack of atmosphere, sun's temperature, etc., and how they would effect the games as we play them on earth. Example: Hopscotch, Jump Rope, Baseball, Tag.
4. Make a map showing the predominant industries in various areas of the world. Discuss reasons for their locations. Does the sun have anything to do with this? As Man learns more about weather and climate control, will this distribution of industry change?
5. Discuss what Orbiting Solar Observatory (O.S.O.) has taught us about the sun. How does O.S.O. work? Does the sun have any effect on communications? On transportation? Could it be used as a source of power?
6. Relate the importance of the sun to some project being conducted in the science area in

your class, such as a simple growing experiment involving identical plants grown in the sun - shade. What relationship does this have to previously considered areas, such as industry, recreation, occupations, agriculture, etc.?

7. During a planetarium visit which can augment study in all major disciplinary areas, request that planetarium personnel place special emphasis upon the sun's relationship to the social studies area. Take advantage of such a visit to clarify the relationship between the sun and earth with regard to seasons, temperature zones, etc.

REINFORCEMENT

1. In addition to the direct effect of temperature, allied items such as economic differences should be considered. An effort should be made to point out that the economy may be directly related to the industrial agriculture or social level of a people which in turn may be related to geographic location. It should be noted that such differences may exist within a single country as well as world-wide.

Example: The agricultural South or West compared to the industrial Northeast in the US.

2. There is a wide choice of space related topics that are allied to protective clothing for Man in a hostile environment. These techniques can be easily tied in with other specialized problems growing out of Man's need to adapt to natural environmental hazards or special work situations. Some examples in the work situations are:

a. Asbestos suits for firefighters
b. Welding masks for eye protection
c. Safety shoes and helmets for construction workers
d. Gas and dust masks for miners
e. Facemasks and sterile clothing for surgeons.

Tie the previous discussion into methods and techniques employed to protect man against natural environmental hazards in each of the suggested geographic categories. Three techniques lend themselves well to comparison in space, vocational and domestic use.

1. The absorption and reflection qualities of dark and light colors.
2. Insulation through the use of new materials and weaving techniques that assist in the retention or dissipation of body heat as required.
3. Creation of an artificial atmosphere within the suit or working space to which Man is confined.

Some suggested topics for other related consideration are:

1. Specialized clothing that may be required for work inside and outside the space or ocean vehicle.
2. Methods of dealing with extremes of pressure and temperature.
3. Marked "opposites" that must be dealt with in these two types of exploration. Example: vacuum of space/pressure of deep ocean. Harsh temperature changes of space/comparative constant temperature at ocean depths. Several sunrises and sunsets each day for astronaut/constant dark for astronaut.

At this point it might be interesting to relate to commercial East-to-West plane travel. The traveler going from Boston to Los Angeles gains two hours--loses them on return. This upsets his natural time clock and affects his efficiency and comfort. It sometimes takes a day or two after such a trip to get back in "stride".

3. Consideration of what would happen to familiar games played on the Moon provides a good transitional discussion that can lead easily to application of the same problems to work situations. Make a selection of several common actions involved in simple work such as:

a. Hammering a nail
b. Sawing a board
c. Tightening a bolt.

Have the class chart comparisons of what would happen if the same work "actions" were attempted in space and in deep ocean environment. Space scientists have developed many special tools and techniques for working in space. Some of these might lend themselves well to oceanographic projects. Point out or make available some of the available NASA reference material on this subject.

4. Domestic applications of the solar heating technique have been demonstrated by M.I.T. scientists. There are examples of such homes in the New England area. This technique, sufficiently developed, might make domestic dwelling and industrial housing more practical in areas where continued cold is a limiting factor economically.

5. The use of the sun as a source of energy is demonstrated well by the use of solar cells aboard the O.S.O. and most other scientific satellites that require electrical power in orbit. Solar cells are being tried experimentally to power emergency telephones on California freeways and the field of energy conversion of this type points to many practical applications.

6. What effect is obvious if the sun were cut off for long periods of time in an agricultural

situation? This same limitation might apply to earth-bound solar cell energy sources. The fuel cell may prove to be more useful for this reason. Compare the two techniques and discuss advantages and disadvantages of each type.
7. An effective method of emphasizing the importance of the climactic effects of the sun is to isolate a given work function such as simple excavation of earth with a shovel and then consider the varying complications of completing this task in all imaginable environments such as space, tropics, Arctic, etc.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA-NSTA - Investigating Science with Children Series, Chapt. 5, Vol. 6, Space: Costa/Teachers Publishing Corp., Darien, Conn.
NASA-NSTA - Investigating Science with Children Series, Chapt. 2, Vol. 1, Wailes/Teachers Publishing Corp., Darien, Conn.
NASA Film: "HQK SR5": Suited for Space, 1966, 28:30 min. Sound. B&W.

TOPIC 2.03

People of the world live together - not independently of one another.

LEARNING ACTIVITIES

(K-3)

1. Plan a jet airplane trip to a far distant destination. Visit several different countries en route. Find out what effect increasing travel speed and distance has on local customs, language and international relations.
2. Make a travel map showing comparisons of time required to make the same trip to major capitals of the world via:
   a. Air transportation
   b. Oceanliner
   c. Land transportation
   d. Combinations of b. and c., a. and b., or a. and c.
3. Compile visual material to illustrate an exhibit devoted to "Famous Firsts". Confine it to aviation and space history. Include all countries.
4. Create a blackboard mural or bulletin board cutout maps of the world. Locate all tracking networks used by NASA, Air Force, and others for tracking satellites or as part of the country's defense system. Discuss the necessity for international cooperation in such ventures and point out potential for improved international understanding as a result of such programs.
5. Conduct a class research project aimed at discussion or report on international cooperation in space. Prepare a list of projects in which the U.S. has cooperated with other countries. Identify the purposes of each project, dates, cooperating country, cost responsibility, etc.
6. Compare the United States and Russian efforts. Why is the "Space Race" concept misleading? What aspects of the competition between the two countries tend to perpetuate this concept? Point out those areas in which the two countries have cooperative agreements in space effort. (Refer to project completed previously in 5.)

REINFORCEMENT

1. It is necessary that the student consider the "contributory effect' of improved aeronautics. It should be emphasized that aviation alone cannot bring about radical change except as one of many things that an emerging nation or isolated region must take advantage of in order to realize its maximum potential. Example: A country with export problems might be well advised to invest in processing plants and construct an airport facility rather than develope a costly air capability of its own, thus encouraging established airlines to seek their trade without first line investment in airplanes. Other such examples are easily identified by the student and can be organized into information supporting an exhibit or class project dealing with other phases of aviation.
2. Collect examples of actual export systems used by isolated countries. Discuss alternate systems that would provide more efficient trade. Point out investment required for necessary facilities or improvements and determine whether or not costs could be practically offset by increased efficiency or widened trade potential.
3. After creating such a file it can be used in combination with materials developed in other topics to illustrate interdependence as found in the cooperative space programs shared by U.S. and other countries. It can be used equally well to illustrate the prestige factor that goes to the country from which the "first" came. Example: the first country to complete a suc-

cessful moon landing will enjoy an immediate rise in international prestige, both from a scientific standpoint and from the standpoint of practical world politics.
4. It is true that countries with widely divergent political and social beliefs have been able to reach agreement in areas where mutual interests are concerned as in certain scientific experiments, international mail and telegraph, international travel. The value of these areas of agreement is that it provides diplomatic sources an entre to widening circles of understanding between countries.
5. What has the United States been forced to do in order to fill gaps in its tracking network caused by lack of cooperative agreement with countries controlling certain strategic spots in which the U.S. would like to place an installation?

TOPIC 2.04

World communication is changing rapidly due to communication satellites, computers, aviation development, and other aerospace technology.

LEARNING ACTIVITIES

(K-3)

1. Make a time-line of communication from the smoke signal to the Syncom of today.
2. Through the use of a visual project such as a chart or mural or exhibit, compare methods of sending messages from early days to the present.
3. Trace the processes through which a letter goes in its delivery from the time it is dropped into a letter box in Paris until it reaches its destination. How might written or printed material be sent via satellite?
4. Make a diagram or use NASA-provided material to show how three Syncom satellites can provide world-wide coverage.
5. Discuss the fact that communications satellites can send many messages simultaneously. Devise some involvement activity to illustrate the principle involved in unscrambling the thousands of bits of information sent to Earth by satellites.
6. Discuss the part that aviation continues to play in delivery of mail. Collect material to illustrate some of the problems involved as we build planes that go higher and faster, thus making shorter delivery trips less practical. What happens to communities in between the major airports, such as New York, Chicago, Denver, and Los Angeles? Use the NASA film describing the development of special purpose aircraft, such as slow and vertical takeoff and landing aircraft. What is their advantage in relation to communication and transportation?

REINFORCEMENT

1. It is important to point out the effect of new techniques in communication upon existing systems. A good example of this is the combination of telephone and radio via satellite. A further example is telegraphic messages sent to a relay type satellite for storage and instantaneous re-transmission whenever receiver capability is open. Compare this to direct attempts at communication to Europe by phone or other methods involving human control. In such a case the caller is held up until operator can get a clear line through repeated attempts. In the case of a satellite tied into a computer, open lines are immediately detected and stored messages relayed immediately. This process could repeat itself many times in the time it takes to dial one number and get a busy signal or traffic delay.
2. a. On each element of the suggested exhibit identify the time, distance and type of signal that could be transmitted. Example: code, voice, visual image.

b. To illustrate interplay in developmental research, elements of this display could be color keyed or connected in some manner to show combinations of communications that make up our various systems. Examples:

1. Phone to telegraph to phone or personal delivery in completing a telegram.
2. Phone to radio to satellite to radio receiver to phone in completing an overseas phone call via satellite.
3. Computer to transmitter to satellite receiver to controls in completing guidance and control functions in spacecraft.
4. Camera to TV to encoder to transmitter to receiver to decoder to TV in completing a message from a satellite photographing the moon, to earth.

3. Any satellite with TV capabilities could handle printed or written transmission. Discuss the impact that this type of transmission might have on some aspects of commerce and industry. Examples:

a. Visual entries on international time tables for transportation which might reflect local changes all along a travel route from origin to destination - as they happen. These could be displayed via TV and the information used by schedulers, passengers, and all other persons involved in a given trip. Compare this to present method where arrival times, delays, etc. have to be phoned or wired from point to point.

b. Point out that identical information in letters that must go to several people will suffer appreciable receipt time differences. Fac-

simile transmissions could reach several points simultaneously.

c. What are the inherent disadvantages of letters or documents mailed in the standard way? Examples:

1. Possibility of loss or damage.
2. Peak traffic delay or length of time normally required for delivery.

Discuss the effects such delay or mishap might have on business or domestic situations and discuss how some of these pitfalls might be avoided through use of new transmission techniques.

d. Point out that satellites in synchronous orbit with the earth appear to remain stationary in the heavens. Refer to the navigation concept in this section to dramatize other uses that such satellites serve.

4. Satellite Communications Game. (This format can be easily extended to include more complex functions where the level of understanding warrants it. Conversely it can be simplified to illustrate simple transmission of a single signal from the satellite to the ground.)

Explain to the class that many messages can be sent at once over a space communications system. Set up a hypothetical situation such as the following:

Man is sending a scientific satellite to a far distant planet. It will land softly on the planet and will be asked to send back continuous information about four things on the planet.

1. Temperature of planet
2. Temperature of atmosphere around planet
3. Any vibration of the planet such as quakes, volcanic
4. Temperature inside satellite

On board the satellite is an instrument that detects each of these and feeds it to the radio which transmits it back to Earth. All four instruments are feeding information at the same time. With all this information mixed together how do we know what is going on in each of the areas we want information about.

Select four children who will represent the detector instruments (1) (2) (3) (4). Select one child who will represent the radio.

Assign a sound to each child representing detector instruments. Example:

(1) Temperature of Planet Detector - girl - high pitched "beep" sound.
(2) Temperature of Atmosphere Detector - boy - low pitched "boop" sound.
(3) Vibration of Planet Detector - girl - normal pitched "beep" sound.
(4) Satellite detector for temperature - boy - normal pitched "boop" sound.

Provide each "Temperature detector" with a code card, marked with digits 1 through 4 with a temperature reading beside each digit. Provide the "Vibration Detector" with a similar card with the digits 1 through 4. Beside each digit enter descriptive words such as: normal, slight, frequent, severe.

Arrange the four "detectors" in a circle with the "radio" in the center. The child representing the radio will turn clockwise and point to each detector in turn. When the radio points at the detector, the detector will respond with any number of sounds listed on the code card.

Example: Radio points at detector (1). Detector (1) responds with three sounds. On the code card we find that three "beeps" signifies 400 degrees. So we know the planet temperature at that moment is 400 degrees. Then in turn each detector will respond repeatedly as the radio turns.

On the blackboard will be a chart duplicating the code cards.

Planet Temperature		Atmosphere Temperature		Planet Vibration	Satellite Temperature	
1	200°	1	250°	1 Normal	1	72°
2	300°	2	350°	2 Slight	2	82°
3	400°	3	450°	3 Frequent	3	92°
4	500°	44	550°	4 Severe	4	102°

As planet temperature is reported either the class or a single student can translate the "beeps" into a corresponding temperature reading or description word. These readings will be placed in columns under each of the four readings. Therefore if you have radio turn ten complete revolutions, you will get ten signals from each detector and the columns might look like the columns shown in the table below.

You can illustrate many things with this result as well as the idea of multiple messages. You might average the columns to determine mission averages or cross refer at a critical point to show whether or not there were related fluctuations across all four categories. YOU ARE ACTING AS EARTH BASED RECEIVER AND COMPUTER. You receive message, decode it and analyze it just as a space communications system might do.

To illustrate how the signal might actually sound, have the "radio" turn more swiftly and do not attempt to write down the message. To further illustrate this point you may want to use available films or sound tapes of actual signals.

5. The impracticality of high altitude supersonic aircraft from a delivery standpoint is that the aircraft would be too expensive for repeated interim landings. It is only at peak efficiency at high altitudes and sonic boom would be a major problem as it fought for altitude and speed after take-off. Vertical and slow take-off and landing aircraft are being developed under NASA aeronautical research programs. These special purpose craft have strong application potential for short haul and difficult access landing strips. A simple graph can be constructed that shows these principles in graphic form. Use the baseline to represent Boston to Tokyo with intermediate stops in Springfield, Hartford, New York, Washington, Chicago, and Los Angeles. Use the vertical scale to represent altitudes in 1000's of feet up to 100,000. Show type of aircraft that would best be used between Boston and all intermediate points. Example:

Boston to Springfield
Boston to Hartford
Boston to New York, etc.

Chart arc from take-off to landing showing altitude, speed and distance.

Planet Temperature	Atmosphere Temperature	Planet Vibration	Satellite Temperature
200°	250°	Normal	72°
200°	250°	Normal	72°
200°	450°	Normal	72°
300°	450°	Slight	72°
300°	550°	Slight	72°
400°	450°	Slight	72°
400°	550°	Frequent	82°
300°	450°	Frequent	82°
200°	250°	Severe	102°
200°	250°	Normal	72°

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

EP-21 Teaching to Meet Challenges of Space Age, Pages 24 & 25.
EP-40 Communications Satellites
NF-21 V/Stol Aircraft.
NF-28 The Laser
NASA Film: "Ticket Through the Sound Barrier" B&W, Sound, 28:02 Min., 1966.
NASA Film: "Echo In Space," Sound, Color, 14 Min.

TOPIC 2.05

Weather plays a very important role in Man's life.

LEARNING ACTIVITIES

(4-6)

1. Construct a weather map of the US and assign individuals daily responsibility for posting weather data. Teach working symbols for various weather factors.

2. On the map, outline a permanent indication of the area in which the student lives. Example: West Coast, Rocky Mountain area, East Coast. You can obtain nephanalysis, A.P.T., facsimile copies of the Tiros weather satellite analysis charts from any major air-

line dispatch office. These come in frequently during each day and serve no purpose after the airlines have posted the information. It is also possible to obtain charts of the satellite sweep, North to South, over your particular area. Discuss the transportation improvement this provides in forms of comfort, safety, and operating economy.

3. How does such widespread coverage affect other areas critical to Man's well-being? Agriculture? Industry? Recreation? Communication?

4. Using the indications on the weather map, attempt a long-range forecast of weather for your area--for one or two days ahead. Discuss the economic importance of dependable long-range forecasting.

5. In the current events period, touch on recent reports of storm damage, hurricanes and other weather phenomena, pointing out cost in time, lives, replacement, etc.

REINFORCEMENT

1. Several techniques can be applied to this daily weather record.

a. A felt board with eastern area permanently painted on its surface and felt symbols that can be moved day by day.

b. Poster painted outline of area on portion of blackboard with chalk indications of conditions changed daily.

c. If steady source of airline weather facsimile sheets is available they could be posted daily in combination with local newspaper forecast and student temperature and cloud or precipitation observations entered directly on the sheet.

d. Assignment of a "weatherman" from the class for one week periods. He might make a morning report of short duration each day.

2. Previous forecasting systems were more general. Today's satellite systems pinpoint problem areas allowing planes to avoid turbulence or storm systems. In conjunction with the weather map it may be of value to indicate deviations in the airline route day by day. Two basic methods of avoiding weather would be sufficient to include: (a) gain altitude or fly over turbulence and (b) maintain altitude and fly around or between major trouble spots. This would dramatically reinforce the idea of the effect of weather in transportation.

3. The interrelationship of the effects of weather can be dramatized by simple examples of what would happen in each of several categories as a direct result of weather.

Example: Ski-lift--late season--or a midwinter rain or thaw period. What would this mean to owners of the ski area; the local shop keepers; general economy of the region?

Example: A storm destroys a power center supplying an industrial area such as New England. What would the effect be on transportation, communication, industry, recreation?

The justification for such discussion lies exclusively in the strength it lends to the interdependency of all facets of our society. No single aspect of our daily life can be adversely affected without "bounce effect" throughout our economy.

4. An interesting related discussion could be based on historical events that have been controlled by weather.

Example:

1. Wars have been slowed down or changed in emphasis.
2. Entire economy of a region has been adversely affected.
3. Major failure of staple crop such as wheat affects entire social progress: Chinese wheat crop failure adversely affected Red economy and was partially responsible for failure of an industrialization seven - year plan.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Neph-Analysis Facsimile charts available from airline dispatch offices.

EP-6 Space, the New Frontier

EP-27 Meteorological Satellites

Films:

"Keeping an Eye on Ginny," 1965, NASA HQK126, sound-black & white, 27 min.

"Tiros: Experimental Weather Satellite RCA," 1961, NASA HQA 25, sound-color, 14 min.

"Tiros II: Experimental Weather Satellite RCA," 1961, NASA HQA 31, sound-color, 6 min.

"Trial Balance," 1965, NASA HQ 123, sound-color, 25 min.

TOPIC 2.06

Since our early history Man has tried to solve navigation problems.

LEARNING ACTIVITIES

(4-6)

1. Plan a total involvement project for the class including exhibits, murals, charts, etc. The theme of the project could be a comparison of problems common to all explorers facing uncharted voyages. To emphasize Man's progress it is suggested that four widely divergent examples be used as the basis for comparison. For example, the voyages of Magellan, Lindburgh, John Glenn, and the first astronauts to the Moon.
2. Using any of the approaches included in the total project draw comparisons between the four exploration eras in terms of:
   a. Navigation techniques employed
   b. Special equipment needed
   c. Kinds of maps used
   d. Distances involved in time and miles
   e. Rate of travel (speed)
3. Discuss advantages of a Man-made navigational system over natural star navigation.

REINFORCEMENT

1. One of the less obvious factors that bear discussion is that the element of danger faced by history's past explorers was greater because scientific support was not as extensive. They worked within a framework of far less technical and general knowledge about their goal than today's space explorer does. This is not to minimize the very real risk faced by astronautic explorers but rather to point up the importance of the rapid technological advancement associated with space age. This leads well into the next conceptual area where hazards of exploration are more fully discussed.
2. a. Similarities are as interesting as the contrasting differences. For example the sextant or some form thereof has been used for ages and in more sophisticated form still exists in space navigation.

   b. A sharp contrast can be drawn between simple hand held navigational instruments of the past and systems used in space travel that involve computers, decoders, transmitters, satellites, etc.

   c. The similarity between the conjectural and incomplete maps available to Columbus or Magellan, and the star maps available to astronauts is an interesting parallel. Equally interesting is the confirmation of accuracy of today's world maps, possible through photographic or visual scanning from space.

   d. There are several interesting subjects related to this problem. A good example is the various limitations that have restricted Man's mobility at different points in time. Examples:
      1. Ocean travel - weather/size of ship/limits of sail/steam, etc.
      2. Aircraft - weather/power/sound barrier
      3. Space travel - power source/vehicle design/atmospheric heat/life support systems for pilot/time-vast distance
3. A simple but effective activity that will lend considerable force to the idea dealt with in this paragraph can be set up easily in any classroom. All that is needed for demonstration is a spot-type flashlight, a mailing tube, and a 45° triangle. Draw a chalk line on the floor completely across the front of the room:
   1. Place flashlight on end in center of line with spot of light shining on ceiling. Mark circle around flashlight position. Label circle Omaha, Nebraska.
   2. Tape mailing tube to 45° slant of large wooden 45° blackboard triangle.
   3. Place base of triangle on easily moveable table or high stool so that tube points toward ceiling at 45°. Tape securely in place on table or stool. Using two legs of table or stool as a guide move directly along chalk line away from center in other direction until spot can be seen through tube. Mark position of table or stool leg farthest from center of line and label spot San Francisco.
   4. Start back at middle point and move in opposite direction until spot can be sighted through tube. Mark this spot as in step 3. and label Boston.

   After setting this up have several students take sightings by moving table until they locate the spot and observe that they are standing in Boston or San Francisco. Point out that a vertical or direct overhead sighting would put them in Omaha. This illustrates the advantage of a fixed navigation point such as a synchronous satellite. The disadvantage is equally easy to demonstrate by moving the spot as the student takes a sighting which will put him over an unlabelled section of the line which represents being lost or in an unidentifiable position.

   This exercise can be tailored to the sophistication of the class by adding the concept of using a moving satellite in a dependable orbit for a reference point as well as the synchronous type.

   With a satellite traveling in a given orbit its position at different points of time will always be known. To fit this concept to the previously described experience the teacher

would merely establish several angles for sighting the tube at each geographic point on the chalk line. This would allow spot to be moved and checked at given angles at predetermined points in its movement to confirm location.

Example: With sighting tube placed on the point labeled San Francisco sight with tube at 45°. Then sight at 30° and move spot until it comes into view. Explain to class that movement might be in terms of an hour or two across the sky. Thus a 45° sighting that establishes San Francisco at 2:00 p.m. could be reaffirmed at 4:00 p.m. with a 30° sighting because we know exactly where the satellite is on its sky track every hour every day. Point out involvement of several sightings as compared to constant single check possible on synchronous satellite.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA-NSTA, "MAN'S CONQUEST OF SPACE," Scholastic Book Services, New York.
National Geographic, November, 1966, THE EARTH FROM ORBIT, Lowman.
EP-6 Space the New Frontier
EP-25 Space Exploration
EP-27 Meteoroligical Satellites and Sounding Rockets

TOPIC 2.07

Space travel, as all exploration of the unknown, can be hazardous.

LEARNING ACTIVITIES

(4-6)

1. Discuss Admiral Byrd's exploration of the Antarctic. What problems did such a mission have in common with space exploration. Examples:
   a. Specialized (equipment) for travel, work and personal protection.
   b. Protection against hostile environment.
      (1) Clothing
      (2) Food
      (3) Housing
2. Plan an imaginary trip into space and list items needed for the trip. Discuss provisions that are made for the safety of the astronaut:
   a. During launch phase of flight
   b. An actual flight
   c. During descent from orbit
3. Collect biographical material on explorers of our age such as Admiral Byrd (Antarctic), Piccard (Stratosphere) and recent astronauts. Discuss reasons why Man risks his life to explore the unknown.
4. Discuss reasons for willingness of a country to finance and support exploration throughout history. Do the same reasons still hold true for space exploration?

REINFORCEMENT

1. An important element for development in this area is the logistical support needed for such an undertaking. As with Byrd it was necessary to employ Navy transport, hundreds of specialists in clothing and housing design, photographers and so on - it is increasingly true that more and more kinds of people are involved as the problems multiply in more sophisticated exploration such as space. A de-emphasis of the astronaut as the key to success in space is a more realistic approach. This points up the wide variety of critical career or job areas that are involved in any major undertaking. More to the point, it allows the classroom teacher to make direct reference to the importance of those basic disciplines with which the student is involved each day.

The direct relation to the hazards of exploration is the fact that in all areas of original investigation there is inherent danger because of the potential for mishandling of unknown factors or materials or forces. In essence it would be misleading to equate the dangers of any exploration with the physical danger to the crew alone for this would be only about one tenth of the complete picture.

2. In the case of unmanned exploration safety is an equally important factor. Provisions must be made for:
   a. Destruction of uncontrolled vehicle
   b. Retrieval of certain instruments or hardware
   c. Protection of launch site personnel

This further reinforces the concept that danger is not directly proportionate to Man's personal physical involvement in a flight, but touches on many other facets.

3. There are any number of practical reasons that force exploration that include:
   a. Search for natural resources
   b. Solution of scientific problems
   c. Population growth
   d. National prestige or political strength

In addition there is an equally important area for discussion in the mere fact of human curiosity which is an integral part of the intelligence that sets Man apart from other animals. It is of value to underline the fact that explorers of note are usually something more than mere pilots or navigators. Byrd and Pic-

card were recognized scientists as well. The requirements placed on today's astronauts puts them in a category of technical competence and scientific qualification far beyond that which would be necessary to qualify merely as a navigator or pilot.

4. Some suggestions for discussion topics under this subject area are:
   a. International prestige
   b. Development of natural resources
   c. Widening trade potential
   d. Land aquisition to accommodate domestic or industrial growth
   e. Protection in a military sense
   f. Scientific pre-eminence

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NF-9	Manned Space Flight: Projects Mercury and Apollo
NF-23	Manned Space Flight: Apollo
NF-27	Living in Space

Films:

"Food for Space Travelers," NASA 1966, sound-black and white, 28:30 min.

"Landing on the Moon," NASA 1966, sound-black and white, 28:31 min.

"Space Medicine," NASA 1966, sound-black and white, 28:31 min.

"Suited for Space," NASA 1966, sound-black and white, 28:30 min.

TOPIC 2.08

Our nearest neighbor in space is the Moon.

LEARNING ACTIVITIES

(4-6)

1. Using available charts, graphs and other publications keep a class scrapbook on project Apollo. The information gathered can serve as reference in investigation of the following space related topics based on the first actual moon landing.
2. Create a chart or visual representation that will graphically display the impact of the first lunar landing will be upon the following categories of people:
   a. Earth scientists (biologists, chemists, metallurgists, physicists)
   b. Politicians (in the larger sense of the top leadership of all countries of the world)
   c. Space scientists
   d. Military
   e. Cross section of career designations (doctor, lawyer, draftsman, mathematician, etc.)
3. Discuss ways in which exploration of the Moon can benefit Mankind in:
   a. Medicine
   b. Industry and commerce
   c. Domestic products
   d. International relationships
4. Have the class choose a well documented period of exploration in the past and trace the same elements as those discussed in previous experimental topic.

REINFORCEMENT

1. The capsule section of Apollo lends itself to easy construction of mockup model, being essentially a simple cone. Sufficient information is available to allow students to approximate the cabin arrangement, windows, doors, instrument panels, etc. Such an exhibit might serve well as the central theme of an exhibit that could be the focal point for total involvement of the class in researching elements suggested under this concept.
2. The suggested topics under each of these subject areas form a natural division for the exhibit suggested above. By dividing the display into two sections, one could be devoted to the effects of successful moon exploration upon careers and job possibilities and the other to benefits accruing to mankind in those areas that are critical to our way of life.
3. It is suggested that a period of expansion be chosen as opposed to a single exploration trip. The Moon exploration is only an integral part of a much larger picture - space exploration. It is important that young people are aware of the scientific aspects of the U.S. programs as well as the more glamorous manned flights. Many facets of the program have been woven into this guide and this is an opportunity to pull them together in what might be considered a review or consolidation of many ideas thus far considered. While the theme of this exhibit would be Apollo and the Moon it can serve a more comprehensive purpose by clearly establishing the realization that this is only the first successful step toward further space investigation and therefore makes the potential of Martian exploration and more complex scientific investigation more probable.

For example let us take one segment through the kind of development that your student might follow with any of the many suggested areas or subjects that he identifies in the exhibit section dealing with the impact of a moon landing on certain careers. Consider the space scientist. It might be organized as follows:

Effect of moon landing on space scientist:

a. Dependable knowledge of types of hazards encountered by astronauts, allowing him to design new devices for direction, protection, etc.

b. Provides a launch platform that makes deeper space travel more simple in terms of required launch power, vehicle design, etc.

c. Provides a permanent communications base that could be used much as our present man-made satellites are used.

d. Opens a whole new field and attendant problems related to establishing manned moonbase, supplying the base, transporting replacement crews, etc.

The number of possibilities are limited only by the imagination and research employed by the participants in the project. Generally speaking an arbitrary limit of four, five, or six ideas in each category should result in a comprehensive project. The involvement of each individual can be tailored to his capacity because of the wide spread of subjects available for development.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA Poster Series - Project Gemini; four 30" x 40" posters/full color showing key aspects of Gemini program. Available on loan from NASA Educational Services Office in your area.

NASA Poster Series - Project Mercury; eight 30" x 40" posters reviewing history of Mercury flights, astronauts, capsule, etc. Available on loan from NASA Educational Services Office in your area.

NASA Poster Series - Communications Satellites; eight 30" x 40" posters dealing with development of global communications satellite system. Available on loan from NASA Educational Services Office in your area.

NASA Publication "NASA - 20th Century Explorers" NF-23 Manned Space Flight: Apollo

NASA Films:

"The First Soft Step," HQK-SR1, 1966, sound, B&W, 28:38 min.

"International Cooperation in Space," HQ-60, 1965, sound, color, 23 min.

"Landing on the Moon," HQK-SR2, 1966, sound, B&W, 28:17 min.

"Returns From Space," HQA-156, 1966, sound, color, 27 min.

"Space Medicine," HQK-SR8, 1966, sound, B&W, 28:31 min.

"Your Share in Space," HQ-56, 1962, sound, color, 27 min.

TOPIC 2.09

Maps show location and interrelation of geographical points

LEARNING ACTIVITIES

(4-6)

1. Point out photo mapping techniques and relate to present space projects which will allow us to map the moon accurately. Give emphasis to the following:
   a. How were maps prepared before Man could get far away enough to photograph the earth?
   b. How were moon maps prepared before the Space Age allowed us a "close up" look at the Moon via Ranger, Surveyor, Lunar Orbiter?
   c. Why is it important to map the Moon in the general area of Man's intended landing?
2. Discuss symbols and techniques used by map makers to designate special areas, features and information.
3. Collect various types of maps and discuss specialized purposes they fulfill.

REINFORCEMENT

1. Have the class pretend that they were living on the Moon and had all the means available to Man for mapping EXCEPT THE SPACE AGE TECHNIQUES. Discuss such areas as:
   a. Would they know whether or not Earth was inhabited
   b. Would they be aware of cities and man-made installations
   c. Would there be features on the Earth that would appear moon-like
   d. Would the land areas seen from the Moon prove Earthman's maps to be fairly accurate

An excellent comparison of earth and moon similarity from great distance can be graphically illustrated by showing aerial photographs

of the Barringer Crater in Arizona and a NASA photo of a Moon crater.
2. Locate on a Moon photo regions that Man has photographed, landed unmanned vehicles upon, and intends to land manned vehicles upon.

REFERENCES and RESOURCES

National Geographic, THE EARTH FROM ORBIT, November, 1966.
EP-25 Space Exploration - Why and How
EP-39 Report from Mars - Mariner IV
Film: "Ranger IX TV Pictures of the Moon," NASA HQ-133, 1965, sound, B&W, 6 1/2 min.

TOPIC 2.10

Man constantly seeks new lands and better ways of satisfying his needs.

LEARNING ACTIVITIES

(4-6)

1. Make a comparison between the pioneering astronauts and our early Western pioneers.
   a. What dangers do they have in common?
   b. What advantages do the astronauts enjoy over the Western pioneers in facing unknown factors?
   c. What other problems do all pioneers share?
2. Make a chronological table showing the outstanding contributions to space progress from the advent of the Sputnik launch in 1957 to present. Include all countries and both scientific and manned space flight events.
3. Investigate new types of materials that have been developed specifically for launch vehicles and satellites.
4. The space program has affected many industries. It has created many new jobs and specialization areas that did not exist ten years ago. List some of the industries that have grown directly as a result of the space program and compilile a related list of professions and jobs that have grown with them.

REINFORCEMENT

1. "Pioneering" has been touched in previous experiences and discussions. The main purpose of reconsidering it at a more mature level is to consider the increasing complication of problems that typified most exploration.
2. An interesting related project could be a list of projects that involved cooperation between the U.S. and other countries. A specific effort should be made to clearly identify only space exploration projects - purposely.
3. List those materials originally developed for space use which have since found use in domestic and industrial products. An interesting chart comparison can be made using space developed materials on one side and domestic and industrial applications on the other.
4. Divide the class into sub-groups and have each group investigate and submit a report or scrapbook or display that illustrates benefits accruing to mankind as a result of his successful lunar trip. Assign areas to each group as follows:
   How could Man's trip to the Moon benefit:
   a. Medicine
   b. Manufacturing
   c. Domestic products
   d. Agriculture
   e. Communications
   f. Transportation

INTRODUCTION: INTERMEDIATE LEVEL

(7-9)

Drawing upon the spread of experiences covered in the primary section of this guide we should now begin to build an understanding of processes and interrelationships at a more mature social and technical level, thus adding depth to the broad concepts thus far considered.

General Objectives:
1. To develop a concept of space and the universe in relationship to earth oriented problem areas and establish an understanding of the justifications for the aeronautics and space exploration programs.
2. To furnish sufficient involvement experiences to provide a practical basis for understanding space experiments being conducted by NASA, Air Force and private industry.
3. To promote growth in scientific attitude.
4. To develop desirable character traits through consideration of Man's inspiration or reasons for advanced research and technology as dramatically illustrated by the space effort.

Satellite Telemetry Receiver, Boulder, Colo.

TOPIC 2.11

A functioning society involves movement and connection. We live in an interdependent world. The aerospace progress increases this relationship.

LEARNING ACTIVITIES

(7-9)

1. Using a globe, identify far away places that the class can locate. Using their city as a starting point, stretch a taut string between their city and the foreign geographic points to determine the shortest distance possible.
2. Locate major ports and airports around the world. Collect pictures and information regarding major imports and exports.
3. Indicate on world map where major intercontinental undersea communications cables now exist. Point out difficulties involved in such telephonic communication. For comparison have a student hold a small sphere six or eight feet from the globe representing a communications satellite. Illustrate how a message or signal can be bounced or relayed from one point to another by stretching a string from a given point such as Boston, to the satellite and then back to any other given point on Earth such as London or Moscow or Tokyo. Emphasize the following:
   a. Geographical obstacles are not a problem
   b. We can send more signals at one time via satellite than we can be cable. (Refer to experience gained in Satellite Game.)
   c. Satellites can do more than one thing at a time. Ex: A communications satellite can be used for other purposes without disturbing its basic function.
4. Check transportation maps to discover where there is the least and the most congestion relative to air, land, and sea travel. Discuss reasons for this. How can V/STOL and supersonic aircraft change this pattern. How can new concepts of ocean vessel transport affect the situation.
5. List as many items as possible that come to your community from Europe, the Far East, and other foreign sources.
6. Point out the necessity and practicality of cooperation between nations to make air and space travel efficient and worldwide in scope.
7. Based on the preceding experiences develop a series of reasonable conjectures as to the possible use of rockets in such areas as mail delivery, transportation, supply to remote areas, etc.

REINFORCEMENT

1. This experience can be related to the aviation section in the communications concept. Topic 2.04. Coupled with new air speed concepts the shortest distance between points takes on an even more impressive impact in terms of increasing interdependence and closeness of relationship of peoples throughout the world.
2. The information gained through this research will reveal some of the potential for growth in relatively isolated locations that are brought into the world community by improved transportation.

For example, it may be found that major exports of certain areas are high-priced because of cost of shipping to world markets. The establishment of jet airports or modern docking facilities may still be required before those areas can take advantage of transportation improvement. This points up the expansion potential. While no emphasis has been placed on the fact that in this space oriented guide there is a revolution in ocean going transportation that goes hand in hand with the more highly publicized aviation program, this aspect of transportation will play an important role where accessibility is the major problem and shipping time is not critical. These considerations are excellent points of comparison and the basis for evaluation of transportation needs. The pupils can arrive at reasonable conclusions on the basis of facts they research for this experience. Information gained will also augment paragraph 4 of this section.

3. It would be well to point out some simple obstacles to other means of communication in addition to direct line telephone. In television, for example, the message or picture is a line of sight transmission. That is to say, the signal travels in a straight line to the horizon from the transmitter. At that point it must be picked up and relayed by another station. Geographical features such as mountain ranges interrupt transmission. Radio is affected by the change in height of the ionosphere off of which its signals are bounced. It is also adversely affected by weather and sunspot action. In the satellite system these variables are reduced to a minimum.

The basic function of a satellite may be weather reporting but the same capability could be used for world-wide surveillance or continuing on broad experiments such as temperature recording in its orbital path. It is possible that a scientific satellite with information storage and transmission capability could be used in a communications role in an emergency situation. The capability to receive information, commands, etc. and to transmit information of a particular nature involves essentially the same components that a satellite intended

exclusively for communications contains. Therefore it would be used for message transmission if the need arose.

4. This paragraph is intended to provide an expansion of the thoughts growing out of item 2. in this section. The effort in this area should point toward the need to consider all modes of transportation when evaluating the problem. Air and space travel is not the answer in all cases. It may be that the items exported are at such a low value level that construction of airports and actual transportation costs make this mode of transportation impractical. It may be that the best answer lies in a combination of techniques. For example, various out of the way exporters might ship by sea to central receiving location with existing air facilities. The more efficient scheduling possible at such a point would cut cost and overall shipping time to a practical degree. With automation and more efficient propulsion system typified by atomic powered vessels, costs may be brought down due to much smaller crew and cargo handling crews. With non-perishable goods time may not be a major consideration. In this case air transport would not enter the picture at all.

5. In this discussion there is an opportunity to bring out the fact that many people are involved in the movement of goods from source to consumer-in addition to basic transport. Example:

1. The original grower or manufacturer
2. The exporter and importer
3. The wholesaler and distributor and processer
4. The store buyer
5. The sales person
6. The consumer and others

It is probably of value to understanding this concept that an exhaustive list of people and functions be developed around a particular item. Example: What are the movement patterns and people involved in the distribution of Brazilian coffee from plantation to coffee pot?

6. This subject area provides an opportunity to consider the balance of trade concept to whatever degree of maturity the class can understand it. It can also be pointed out that nations that may have vast political and social systems must cooperate in trade agreements for their mutual prosperity.

7. Due to the earth based emphasis in this unit the reaction might be limited to this area in dealing with rocket delivery ideas. This is not intended. Supply, mail, etc. will be a major consideration when a base is established on other planets or when a manned platform in space is successfully launched. Therefore this application of possible rocket delivery should be considered simultaneously with earth related applications.

TOPIC 2.12

Geographic relationships of time, space and distance can be developed on a global scale much more easily through space communications applications.

LEARNING ACTIVITIES

(7-9)

1. Prepare a current event report on the Telstar, Relay and Syncom and Nimbus satellites and their impact on international communication. Use the term "communication" in the broad sense to include sharing of scientific data, weather information, etc., as well as direct voice or video communication. Discuss various peaceful uses to which communications satellites can be applied.

2. Chart the milestones in space communications from 1957 to present.

3. With some visual representation technique such as a model or mobile demonstrate the three point world wide communication theory upon which the Syncom system is based. Discuss potential concepts in terms of:
   a. Military surveillance
   b. Direct communication
   c. Entertainment (world-wide TV, etc.)
   d. News dissemination
   e. Benefits indirectly or directly affecting all people.

REINFORCEMENT

1. This area provides an opportunity to underline the ongoing efforts to establish international cooperative space agreements both in the scientific sense and the social sense as typified by the UN treaty of 1967 against use of space for military purposes.

2. This area is intended to cover the years starting with Russia's launch of Sputnik. These are the generally accepted dates for identifying the space age. There were several successful projects prior to that time, however, that could be classed as space communication in a broad sense. Signals were bounced off of the moon. Radio astronomy has been in existence for over twenty years. Projects such as these would provide an interesting area for additional discussion based on man's efforts to understand space prior to the advent of a successful rocket. Of particular interest in Massachusetts, of course, are the early efforts in rocketry conducted by Dr. Robert Goddard of Massachusetts, now called the Father of the Space Age.

3. A simple demonstration of this capability can be conducted in a semi-darkened room with large rubber ball and three flashlights. By experimenting with the distance from ball to flashlights it is possible to illuminate the ball completely with three sources of light. These light areas correspond to the transmission areas of the satellite system.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

EP-21 Teaching to Meet Challenges of Space Age, Pages 24 & 25.
EP-40 Communications Satellites
NF-21 V/Stol Aircraft
NF-28 The Laser
NASA Film: "Ticket Through the Sound Barrier" B&W, Sound, 28:02 Min., 1966.
NASA Film: "Echo In Space," Sound, Color, 14 Min.

TOPIC 2.13

If Man aspires to a high enough goal, he will be forced to investigate many related problems in order to complete his mission. These related areas may often be fully as important as his primary goal.

LEARNING ACTIVITIES

(7-9)

1. Prompt a spontaneous class discussion of the principal discoveries growing out of the aerospace program to date. List these discoveries and discuss benefit to Mankind.
2. Assign research project to add to the above list; clearly indicate those things that were originally listed before researching and those that come after. Designate those projects that the class feels are most significant and show future development of those areas. These studies could be incorporated into previously developed space exhibit under the general category of "Benefits of Space Exploration to Mankind."
3. Conduct a poll of the class to determine how many parents or relatives are working in fields related to or affected by aerospace research and development.
4. Organize a school-wide assembly at which a speaker would be invited to discuss the NASA program and the ways in which it has followed the mission that Congress gave it. "The Peaceful Development of Space for the Benefit of all Mankind".

REINFORCEMENT

1. This discussion will probably reveal some of the more common things that have resulted from aerospace research such as Mylar recording tape made from the plastic developed for Echo Satellite. They might realize that miniaturization techniques developed primarily for space have affected the size of radios, recorders, and a host of household items. Rechargeable flashlight batteries are directly connected to space needs. These items might be brought in by students for a display based on space developed items used in the home.
2. The reason for the clear definition between those things of which the students are spontaneously aware and those that have to be sought out is to identify the extent to which they are aware of the societal impact of space research. It is true that there may be little response of a spontaneous type - but this in itself will provide the teacher with a solid opportunity to plant some "seed" ideas that will generate a balanced concept concerning the reasons for space exploration - beyond the single moon landing fixation.
3. This will also provide a resource file of potential speakers who may be willing to talk to the class or school on current topics relating space industry to everyday living or in specialized areas under other disciplines.

Attempt to obtain a representative sampling of products, materials, or literature from these sources. Use these materials as display items showing impact of the aerospace industry on the area in which the student lives. This could be an independent project or serve as a section in a career exhibit or industry exhibit.

TOPIC 2.14

Time and distance relationships change radically as space missions extend Man's capability more and more rapidly with each succeeding mission.

LEARNING ACTIVITIES

(7-9)

1. Make a comparative bar chart or graph showing time required and distance covered by several eras of transportation.
   a. First orbital flight (Glenn)
   b. First round the world flight
   c. First overseas flight
   d. First coast to coast automobile trip
   e. First coast to coast railroad trip
   f. Coast to coast trip by sailing ship
2. Chart ocean and air routes on map to illustrate the difference between surface and air distances. Holding a sphere representing a satellite about a foot or two from a globe, hold satellite still and rotate the globe. Introduce the idea that the distance between any two points in the world is only as far apart as a trip to the space station and back.
3. Make a timeline of the History of Flight from 1700 to present.
4. Prepare a special biographical report of explorers and pioneers of space in the 19th and 20th centuries.
5. Make a map of time zones showing gain and loss of time experienced in East and West flight. Use your area time basis for comparison.
   a. Propeller aircraft
   b. Subsonic jet aircraft
   c. Supersonic aircraft
   d. Space capsule
6. How many sunsets and sunrises would an astronaut experience in earth orbit while a person in Boston experienced one of each. How many in comparison with an Eskimo at the North Pole?

REINFORCEMENT

1. An interesting adjunct to this comparison would be comparison of the speed and distance factors in each of the suggested eras with a personal travel experience of the student. Example:

> In the time it takes to travel from Boston to New York (4 hours) how much distance would have been covered by the six methods discussed?

Further comparison could be made on an even more local basis by using the travel time between house and school, etc.

2. Confirmation of this idea is impressively illustrated on a local basis. Using any easily available town maps or regular road maps, the distance in miles can be totalled from map notations between points enroute. By drawing a straight line from point to point and measuring distance according to scale of miles it will be obvious how much shorter an unobstructed straight line route can be.

3. An allied possibility in this area is to identify Man's concern with flight before it became a practical possibility. Example:

   a. DaVinci's hypothetical designs for aircraft
   b. Greek mythology
   c. Jules Verne's story "From the Earth to the Moon"

4. The wide range of knowledge in science, aviation, and interdisciplinary studies required to be an astronaut contrasts sharply with requirements encountered by explorers of earlier history. Information gained during this biographical search could be used to emphasize the differences and impress the pupil with the need for ever expanding knowledge of his age.

5. This can be combined with Item 1 by superimposing this information on the bar chart. Another area of discussion could be the inherent problems growing out of ever increasing speed:

   a. Physical reaction experienced by passengers
   b. Problems of airport to destination transportation time once flight is completed
   c. Overtaxation of airport facilities, etc.

6. The concept of sunrise and sunset is an earth orbit oriented phenomenon. Extension of this discussion to include the relationship of the sun to the space ship in lunar trips or Mars trip. Would day and night conditions occur:

   a. While circling the earth preparatory to escaping into lunar trajectory?
   b. During trip from earth orbit to lunar orbit?
   c. During lunar orbit?

TOPIC 2.15

Weather plays an increasingly important role in our lives. As we understand it more thoroughly and can put this knowledge to use we can improve Man's existence.

LEARNING ACTIVITIES

(7-9)

1. Name as many activities as you can that are affected by weather.
2. Investigate ways in which meteorological satellites can increase Man's productive capacity in agriculture, industry, construction, etc.
3. Discuss the methods by which Tiros and other weather satellite information is transmitted, interpreted and distributed for practical application by farmers, airlines, ect., using the NASA Facts bulletins.
4. Check the disastrous hurricanes affecting the U.S. during the last five years. Pinpoint their origins. Discuss part Tiros weather satellites played in early warning system.
5. Discuss methods employed for weather forecasting prior to Space Program. Point out how invention of telephone, telegraph, teletype, radio and TV have helped speed up weather reports and the part they continue to play combined with Tiros and the NASA meteorological satellite findings.
6. Plan a field trip to local weather station of FAA facility or airline installation where APT system is used in combination with other weather information sources to plot airline courses and control traffic.
7. Document the predominant weather characteristics of several different geographic locations throughout the world and find out how weather affects the people and customs of the areas.
8. Develop the idea of the feasibility of "weather control". What has actually been done. Have any new ideas been presented recently.

REINFORCEMENT

1. Allied with this particular topic are the economic, commercial, industrial and domestic side effects resulting from weather conditions-to the good and bad. Predominant regional weather also has a direct bearing upon health and social customs of inhabitants as pointed out in Activity 7. Combining all of these factors in a review should provide a mature realization of the reasons for the great emphasis that is being placed on improved forecasting techniques. It is also an ideal point at which mention could be made of inter-agency cooperation within our governmental system.

Example: Tiros satellite information is used by the Weather Bureau, Federal Aviation Agency, airlines and many others. Thus duplication of forecasting systems is unnecessary and considerably less costly.

2. Some areas of possible application in long range forecasting are as follows:

a. Dependable long range forecasting could lead to more efficient planting, harvesting and storage practices. Surpluses could be controlled more efficiently and cost levels stabilized in agricultural products.

b. Construction industry could preplan in such a way as to take maximum advantage of permissive weather for exposed work and enclosed work for inclement periods.

c. Industrial scheduling could provide heavy production of products that would be in heavy demand because of prevailing weather conditions over a long forecast period...snow removal equipment, agricultural tools, home building supplies, etc. Theoretically it should be possible to anticipate needs based on dependable long range forecasts in such a way as to have production rise just ahead of peak demand and taper off before drop in demand.

3. In addition to the fact sheets available from NASA it is possible to obtain used APT readout sheets from airline scheduling offices if your request is received a week or two in advance of your need. Also helpful and easily obtainable are teletype weather advisoriee. These two sources provide a good illustration of the combined sources used to produce a useable weather guide.

4. An interesting fact related to this subject is that the recorded savings realized by areas that were able to prepare for hurricanes in advance almost cancel out the cost of the original satellite system that provided the early warning. The further point of interest is that the satellite has a relatively long life and consequently may provide these savings repeatedly, making the satellite an increasingly better investment as it continues to operate.

5. A recently created agency called Environmental Science Services Administration has been created to conduct research and evaluation of the meteorlogical information gained in space in terms of environmental science application.

6. Some Air Force installations have such systems which might be included in a visit if prearranged sufficiently in advance. Other possibilities are: meteorological stations, newspaper, radio and TV stations with wide services, agricultural stations.

7. An alternate experience in this subject area could be an assignment to identify those customs, agricultural and industrial practices, etc. that are peculiar to the geographical area in which the student lives. Identify those items that are specifically related to the predominent weather pattern of the area. These items can be related to economic factor through comparison. Example: clothing and heating costs in New England compared to requirements in Southern Florida.

8. This subject underlines the problem of international cooperative agreements. When actual weather control is feasible, for example, what responsibility would one country have toward another with regard to creating a rain condition; in prevention of storms in a threatened area that may be adjacent to an area that needs water, etc. Consider the recreation industry and the potential value in the ability to create snow conditions in ski areas etc.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Neph-Analysis Facsimile charts available from airline dispatch offices.

EP-6 Space, the New Frontier
EP-27 Meteorological Satellites

Films:

"Keeping an Eye on Ginny," 1965, NASA HQK126, sound-black & white, 27 min.
"Tiros: Experimental Weather Satellite RCA," 1961, NASA HQA 25, sound-color, 14 min.
"Tiros II: Experimental Weather Satellite RCA," 1961, NASA HQA 31, sound-color, 6 min.
"Trial Balance," 1965, NASA HQ 123, sound-color, 25 min.

TOPIC 2.16

Man's determination to conquer Space is inspired by elements of intellectual curiosity, patriotism, and personal convictions. These elements have been the inspiration for all of Man's progress to date and will continue to pace his future accomplishments.

ACTIVITIES

(7-9)

1. Study the early development of practical flight covering Lilienthal's glider, Montgolfier's balloon, Wrights' airplane, Goddard's experimental rockets. Research the practical uses to which these men's inventions were applied and determine whether or not the immediate impact of their work was recognized. Did their respective countries benefit directly in any way during the four or five years following their contributions? Did they personally benefit?

2. Immediately following (1) apply the same criteria to aviation after World War II, development of radio and telephone, orbiting of weather and communications satellites, successful manned space flight and development of supersonic aircraft.

REINFORCEMENT

1. Direct attention to some of the following ideas:

a. Early scientific development was often a one or two man team working in relatively isolated situations.

b. Progress was limited by limited technological capacity in power sources, materials and manufacturing.

c. Communications were relatively crude so that men in different areas of the world, working on the same ideas, could not easily share findings.

d. Drawing on the convictions and inspiration of early pioneers, modern science applies massive manpower and financing that accelerates rate of change through discovery.

e. Communications being nearly instantaneous causes these changes to be global in impact rather than local or regional.

2. Enumerate the qualifications and character traits you feel are necessary in the selection of our astronauts. Explain your selection. Compare these criteria with available information on actual selection process and biographical material on present astronauts developed in previous experiences under time and distance relationships concept.

Astronauts McDivitt and White

INTRODUCTION

SECONDARY LEVEL

In continuing the NASA Resource Guide into the Secondary Level, there is a resultant shift in format. While retaining the spiral nature of the earlier materials, there has been no effort to tag activities and materials to a grade or subject level. Rather, by arranging them in a hierarchy of difficulty, the teacher may select his material for individual groups or classes as they seem suited to the needs and abilities of the pupils involved.

Another stylistic change is to reduce the Topic approach to the single word or phrase concept which may then receive its broadest application, even beyond those suggestions in this project. These concepts will have to be supported by generalizations from the various disciplines developed by the pupils. This is followed by suggested activities for the pupils.

The second approach *is the selection of* several specific concepts, such as globalism, conquest, sovereignty, interdependence and interaction. These units follow the opening format and then develop specific activities which the teacher may use as presented.

TOPIC 2.17

Elementary Topic spiraled: World communications are changing rapidly due to communication satellites, computer development, aviation progress and other aerospace developed techniques.

SUB-TOPICS

Utilization of Resources	Culture
Specialization	Civilization
Internationalism	Interaction
Natural Monopoly	Industrial Revolution

Communications is a concept that lends itself readily to a topical or thematic approach. It has long been considered a reason for man's supremacy over animals. Certainly, as a means of storing and transmitting knowledge, it has been a primary culturalizing force. Whether viewed in a world history or an American history course, the impact of rapid change commencing with the Industrial Revolution is of significant value in understanding today's worldwide communications systems. Of especial importance is the application of electrical and atomic energy to the communication process. In investigating these ideas, much attention should be directed toward the role of the government in either an open or closed society as to the benefits of communication processes.

Costs of communication is an interesting area to develop. Economic, political and social conflict play an interesting role in studying *the history of communications through such* epoch-making phenomena as the Pony Express vs. the stagecoach in the 1860's.

Scientific discovery and technological advances are areas which lend support to the topic.

LEARNING ACTIVITIES

(10-12)

1. Indicate the drawbacks to non-electronic communications systems.
2. In handling the "shrinking world" hypothesis, explain how Echo and Telestar contribute to this phenomena.
3. Discuss the value of the "hot line" in light of: causes of the War of 1812, anti-German attitudes in the US in 1917, Mrs. Kennedy's letters to Mr. Khrushchev.
4. In bar graph or time line form, indicate the history of communications paying especial attention to the acceleration of change in recent times.
5. Activities in this area can be developed through the historical as opposed to the scientific method. The predictive value of history can be successfully utilized.

CONCEPTS TO BE DEVELOPED:

Change resulting from NASA efforts
Communication
Utilization of Resources
Specialization, either Individual and/or Regional
Cybernation: computerization
Internationalism ("shrinking world")
Natural Monopoly

PEGS IN HISTORY

From review of introductions of communication as a basic part of man's culturalization process, the teacher can narrow down into definite periods of communication changes in American history. Early colonial reliance upon coastal vessels over the Maine to Georgia Post Road. The advances and struggles for mail franchises between the Pony Express and the stagecoach, stagecoach and railroad, railroad and airplane.

In developing this issue, the role of government partnership should be underlined either in grants, subsidies, or actual ownership of the process.

From Marconi to Telestar, the role of electricity should be given high priority in determining world events.

REINFORCEMENT

1. Develop a biography of major communication advances since 1837 paying major attention to the device rather than the man.
2. Indicate the drawbacks to non-electronic communication systems.
3. Write a history of the developing automated post office.
4. Explain how Echo and Telestar contribute to the "shrinking world" theory. Indicate the historical, governmental, social, and economic repercussions of this (these) technological advances.
5. Create a working model of computerized satellite communication systems.
6. In thinking about internationalism, discuss the value of the "hot line" in light of: The War of 1812, American sympathies in World War I toward the antagonists, Mrs. Kennedy's statement to Mr. Khrushchev that the fear of John F. Kennedy was that "little men would precipitate a world holocaust." Can better means of communication assure world peace, delay outbreaks of war? Refer to movie, "How I Learned to Live with the Bomb!"
7. In bar graph form, indicate the changes on space and time communication as a result of technological advances since about 2000 B.C., automation and computerization. Such things as facsimile copy, V-mail, telephoto pictures of outer space, etc.
8. Exercises in developing generalizations concerning these concepts and activities should evolve from the historical rather than scientific method. Use ideas in 6 above to search out raw data and have pupils develop possible hypothesis and then generalizations based upon their findings.
9. Cost analysis of each of these communications systems is invaluable. Cost can be approached from view of government investment, private industry, individual designing project, consumer cost, initial and subsequent costs in terms of resource allocation to provide the service, i.e., post office vs. telephone company, etc.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-21 Teaching to Meet Challenges of Space Age, Pages 24 & 25.
EP-40 Communications Satellites
NF-21 V/Stol Aircraft
NF-28 The Laser
NASA Film: "Ticket Through the Sound Barrier" B&W, Sound, 28:02 Min., 1966.
NASA Film: "Echo In Space," Sound, Color, 14 Min.

TOPIC 2.18

GOAL SATISFACTION

Elementary Topic Spiraled: If man aspires to a high enough goal, he will be forced to investigate many related problems in order to complete his mission. These related areas may be fully as important as his primary goal.

SUB-TOPICS

Aspiration
Role (playing)
Problem Solving
Intellectual Goals
Technological Goals
National Goals
International Goals
Prestige, Status, Interaction.
Basic national goal is to be first to the moon in the decade of the 1960's. This goal is based

upon such factors as prestige, military strength, scientific position in the world community, etc. Race has been competitive since Russia's 1957 launch of Sputnik, and subsequent successful manned satellites. Some of this competition is healthy as it supports NASA toward obtaining support for sufficient funding for its efforts. Other aspects are unhealthy as they stress nationalistic goals over world interdependence. There are promising signs of ease in this field because of Executive Agreements which have led to international cooperation in the "moon race". As each country encounters greater problems and reaches solutions, there may be a continued exchange within the scientific community.

LEARNING ACTIVITIES

(10-12)

1. Another result of our goal to reach the moon is the creation of many jobs or roles our citizens can aspire to fill both to assist our country in achieving its goal and to satisfy their own needs as individuals. While the astronaut is foremost in the public eye, there are literally hundreds of jobs necessary for the astronaut to reach his goal.(See vocational guidance section).

Technologically, our society has benefited giving us new products that are by-products of the "moon effort". (See scientific discovery).

While history assists in formulating attitudes about goal satisfaction and would key junior high school discussion, secondary pupils should develop their major hypothesis from sociology, political science, psychology and economics. Much can be done in these areas to give our political institutions a world-oriented outlook.

2. Sociology can show the growth and need of role in an individual's make-up. Economics plays a role again in utilization of our human and material resources. It also stresses factors of production, i.e., land, labor, capital and management. Distribution of wealth is important.

Activity around role of legislature, state government, local and national news media are important. Activities in this unit should be based upon the discipline being utilized:

Sociology (role playing)
Psychology (personality rating)
Political Science: local, state, international competition.

Goal satisfaction; as beyond discovery, inquiry, and knowledge needs. There are individual activities: scientific discovery (astronauts); societal (prestige factors relating to space achievements); international (Telestar and tracking and launching cooperation).

Goal satisfaction may lead not only to competition, i.e., grades, jobs, promotions, Federal vs. private spending, but also to conflict, i.e., by budget battle, show of tax dollar, military vs. civilian control of activities, international discord. From individual nation to individual person. Stress, however, that the nature of the undertaking--exploring the universe--plays down the individual role. From carpenter to teams of astronauts.

History Peg: the individual trapper, the discoverer (Columbus), etc., needed crews, but still had to do an individual selling job.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space, the New Frontier
EP-23	Seven Steps to a Career in Space Science and Technology
EP-35	Aerospace Bibliography, 3rd Ed.

TOPIC 2.19

SATISFYING NEEDS AND WANTS.

ELEMENTARY CONCEPT SPIRALED: Man constantly seeks new and better ways of satisfying his needs.

SUB-TOPICS: Needs (i.e., economic, psychological, intellectual, national):
Utilization of scientific discovery
Scarcity
Resources
Supply and demand
Automation
Cybernation
Production

Although basically an economic concept, "need" in this instance is an extension of man's acquisitive nature to possess that which he can reach.

In order to satisfy this need, he must make decisions about the utilization of resources necessary to achieve these goals. This allocation of men, materials and money is based upon assumptions about the state of his economic well-being, the long-range return if all proves well, and the immediate prestige return from being either first or most or strongest.

LEARNING ACTIVITIES

(10-12)

Assignments in this area should evolve from economic concepts of taxation, spending, national policy found in political science classes, and a problem-solving approach to the problems effected when these needs are attempted to be satisfied or are thwarted.

REINFORCEMENT

This unit ties, vocationally, into the scientific discovery or technological advances unit.

TOPIC 2.20

EXPANSION

ELEMENTARY CONCEPT SPIRALED: driving force in the history of man has been the desire to expand, not only his knowledge but also his control over material things.

LEARNING ACTIVITIES

(10-12)

1. Review the motivation of the great periods of expansion and compare these with the factors which motivate and limit our current exploration of space.
2. If the nations of the world cooperate in joint space exploration programs, what beneficial results might be forecast? What evils might be eliminated? How will it affect the spirit of cooperation? How would such an organization be administered? How would this affect local autonomy?

This concept can be developed at several different levels: (A) Territorial; (B) Extension of a sphere of influence; (C) of knowledge.

It can also be studied from the point of view of several disciplines: (A) Anthropology: culture diffusion; (B) Economics: combines in big business; (C) Political Science: states rights vs. the federal government; (D) American History: extension of the frontier; (E) World History: development of empires; (F) Religion: the Muslim world.

History can supply the content for studying this concept of expansion and students can derive any number of generalizations from the social studies disciplines.

A simple generalization that can be developed from a survey of world history is: a driving force in the history of man has been his desire to expand not only his knowledge but also his control over material things.

3. The student can analyze any period of expansion and develop a set of criteria. For example:
   a. What motivated the Hittites, the Hellenes, the Tartars, Romans, Moslems, Napoleon, Hitler, the Spanish, French, English, Dutch of the 15th and 16th centuries, the American of the 19th century, the barons of industry? What brought about the emphasis on Space Exploration during the past 10 years?

Motivation might be categorized in terms of: a lust for power, the theory of co-variant power, need to compete for survival.

   b. What factors controlled each of these examples of expansion? What resources were available? What percentage of available resources were allocated towards attainment of the goal? How did technology limit or enhance expansion, especially in terms of: the kinds of vehicles available, navigation systems, ability to cope with the environment?
   c. What were the effects?

From each study of expansion should evolve certain criteria for analyzing expansion. How did expansion cause conflict? What kinds of laws resulted from expansion? How did technology affect or limit expansion? How was the process of encultration enhanced by expansion?

The exploration of space is simply an extension of man's desire to expand both his sphere of influence and his control over other territories. Historically, man's desire to explore space is going to result from the same kinds of motivation: curiosity, need for more living space, desire for newer and more abundant natural resources, co-variant power.

Space exploration is going to be limited by the same kinds of factors: resources available and the willingness to allocate these resources, technological advancement in terms of vehicles available, navigation instruments, and ability to cope with environmental factors.

There are going to be the same kinds of effects: conflict rising out of arguments over continuation of the space program, ownership of property, control of space lanes and, eventually, attempts to arrest conflicts will require agreements and laws between nations to regulate space exploration.

Expansion:

In its simplest definition, expansion means the act of enlarging. However, in its broadest sense, it can include ideas related to amplifying, swelling, distending, inflating or dilating.

The history of man living in groups is replete with examples of his concern for and attempts at expansion. These examples range in complexity from a simple expansion of a sphere of influence to expansion of boundaries to include many peoples. The Tartars in the Soviet Union are a good example of the expansion of influence as are the Communist satellite nations' ties to the Soviet Union. The Hellenistic and Roman empires are excellent examples of expansion of territorial borders. The same degree of extension applies to industry in capitalistic countries where the history of large companies points out their attempts at broadening the sphere of influence over related or allied industries as well as the actual buying up of associated industries.

companies points out their attempts at broadening the sphere of influence over related or allied industries as well as the actual buying up of associated industries.

The development of the concept "expansion" should include the development of the understanding of multiple causation and effects. It should include the motivational aspects in terms of generalizations from economics, sociology, and psychology. The content of history can serve as the vehicle for a case study approach to many of the problems associated

with expansion. What affect did an individual's lust for power have on the development of an expansionistic policy? How did the theory of co-valent power enter into expansion policies? How did the need for survival affect expansion?

How did it promote conflict? What means were used to resolve the conflict? How did it lead to a new technology? What role did it play in culture diffusion?

REINFORCEMENT

Once a particular example of expansion has been investigated, then the student can easily make the transition to space exploration if he views it as an example of expansion. Here is an ideal opportunity to present a real challange to the student. Once he has developed criteria for analyzing the process of expansion, he can hypothesize as to how space exploration will affect interaction among peoples of the world, and the kinds of rules and regulations that will ne necessary to promote orderly expansion into space.

A. Each phase of expansion has brought with it a new vocabulary. A few obvious ones are: gun powder, foxhole, intercontinental, ballistics missile; the astrolab, the sextant, the computer; trial by the ruler, trial by ordeal, trial by peers. Each of the above words or phrases suggests a new kind of interaction among peoples and resulted in regulations or laws to control this interaction.

Have the students develop a space age vocabulary. (Interesting sources would be the want ads of the local newspaper, and the yellow pages of a metropolitan telephone directory.)

Develop a chart showing how these terms relate to interaction among people and what kinds of rules or regulations might result from this interaction.

B. Expansion has rarely been the result of a coordinated group effort, more often it has been in competition with other groups or nations, or the result of individual initiative. The race for colonies, the work of Prince Henry the Navigator are good examples. It would be interesting to hypothesize the results of Spanish-English cooperation to explore the New World. Of course, there have been exceptions such as the Line of Demarcation and the division of Antarctica.

If the nations of the world cooperate in joint space exploration programs:
What evils might be eliminated?
How will it affect the spirit of competition?
How would such an argument/organization be administered?
How would this affect local autonomy?

Using the discovery and colonization of the US, of Latin America and of Antarctica as case studies, develop some guidelines to be followed by those nations involved in the discovery and colonization of other planets.

TOPIC 2.21
Conquest.
In a broad sense, conquest relates to overcoming obstacles. The most recent challenge of this nature is our attempt to conquer space. ELEMENTARY CONCEPT SPIRALED: Man's determination to conquer space is inspired by elements of intellectual curiosity, patriotism, and personal convictions. These elements have been the inspiration for all of man's progress to date and will continue to pace his future accomplishments.

SUB-TOPICS:

Inspiration
Nationalism
Intellectual Curiosity
International Rivalry
International Cooperation
Imperialism
Colonialism
Conquest

LEARNING ACTIVITIES:

(10-12)

1. Research the development of space exploration. Start with the development of the V-2 Rocket. Was this the work of one man or was it the result of the interaction of political, social, technological and economic forces?
2. Trace the beginnings of space research.
3. Analyze a particular conquest to develop an understanding of multiple causation as a process in history. Having developed criteria, use them to evaluate the possible effects of space conquests.
4. The simplest definition would denote the defeat of an enemy. However, in a broader sense, conquests relate to overcoming obstacles. Thus, the conquest of space relates to the overcoming of obstacles that impede space exploration. An obstacle that must be faced is fear of the unknown, for any venture from the known to the unknown involves a degree of anticipation. Thus, a chief concern

of explorers is an attempt to provide for a variety of problems without knowing specifically what those problems might be.

The adventurous spirit who decides to explore a cave, realizes the possibility of pitfalls without knowing what to expect. The simplest items necessary for such a trip would be a flashlight and a rope. However, what will be the rate of change in temperature, what animals or reptiles might be encounter? In this instance, the untrained person faces greater risks than does the geologists or botanist who can read the environment. In this simple example, the explorer has the opportunity to make a series of choices, that is, when faced with an obstacle he may leave the cave to obtain some special tool and return to his exploration at a later date. Or, his experiences may lead to the creation of a special tool to be used on successive explorations.

Turning to history, we can find many examples of conquest in all fields of endeavor. However, for student research and discussion, it is well to view these examples from a frame of reference. In this instance, we might view man's conquests as being controlled by the interaction among political, social, technological and economic forces, thus the outcome of the attempted conquest was somewhat predetermined. Or, we might view the conquest as resulting from the decisions and actions of some outstanding individual.

5. The automobile has had a tremendous impact on US society, moving from a simple machine to the core of an economic system it now affects numerous industries, has been responsible for many laws, and is now considered a health hazard. Was the development of this industry pre-determined in terms of the forces of society mentioned above? Do we now have a choice relative to maintaining or expanding this industry?

6. Did the automobile industry result from the decisions and actions of one individual? To what extent did he control the future of the industry?

Each area of conquest can be analyzed from the above points of view.

REINFORCEMENT

1. Research the development of space exploration, start with the development of the V-2 Rocket. Was this beginning the result of the interaction of political, social, technological and economic forces? Was it primarily the results of the work of one man?
2. Trace the beginnings of space research. How was the US program affected by the decisions of one man? How much of it was the result of pressure applied by outside forces? Each conquest has resulted in some good and some evil.
3. Analyze a particular conquest: of a group of individuals, i.e., the Roman conquest of England; of a disease--pasteurization; of production--interchangeable parts. The analysis can result in a chart that would include such headings as: affects on society as a whole, i.e., occupations - new - obsolete; preservation of life - destruction of life; legislation - to enforce or restrict; encultration - hinder or help, destroyed a way of living, created a new way of living; new skills required - old skills obsolete; developed economic growth - hindered economic growth; brought people closer - increased the differences between them.

This kind of an analysis should reflect a cause - effect relationship and reinforce an understanding of multiple causation as a process in history.

4. Having analyzed a situation from the past and developed a set of criteria, the student should now use these criteria to evaluate the possible effects of space conquests. While there will be some conjecture, there also will be an enormous amount of creativity involved in this process and the student should develop an appreciation for the complexity of man's problems and a realization that most problems do not have simple solutions.

THE CONQUEST OF SPACE

The Conquest of Land Travel by the Automobile

Socialization	Legislation	Acculturation	Occupations	Health
How did it foster or hinder urbanization?	1. What laws are a direct result of the invention of the automobile?	1. List ways in which it has either fostered or hindered the process.	1. What occupations became obsolete?	1. How has it affected health?
How did it promote or restrict interaction among people?	2. Divide the laws into categories.		2. What occupations were created?	2. Give examples from medical report and legislation.

The Conquest of Air Travel by the Airplane

The Conquest of Space Travel by the Rocket

TOPIC 2.22

SUB-TOPIC:

History shows a changing pattern of government from the sovereign king to the sovereign nation as a grouping of all the people of the nation. The concept of a sovereign nation is undergoing a refinement because as man becomes more interdependent, he must sacrifice his sovereign power for the benefit of the larger grouping of mankind.

LEARNING ACTIVITIES

1. Through a study of the change in form of government from Articles of Confederation to the formation of the Federal Government, develop criteria for future cooperation in the exploration and colonization of space.
2. Compare problems of colonization and Antarctica with colonization of the moon and/or planets.

The understanding of this idea is relative to the degree of exposure that the student has had with the concept of democracy. A glimpse at history shows the changing pattern of governments which relies upon one's view as to the seat of the sovereign power. Thus, through history we have had a change from the power being in the hands of an individual to a group, to all the people of the nation. In modern history, this concept has been further enhanced by the development of the sovereign nation.

The concept of the sovereign nation is now undergoing a refinement because, as man becomes more interdependent, the more he must sacrifice his sovereign power. For example, to what extent will the decisions of NATO, SEATO, The Common Market, etc., override the desires of the nations that make up the organization?

Space exploration now presents another refinement to the concept of the Sovereign State. How much sovereign power should be surrendered by the nations of the earth in the efforts to explore/colonize other planets? What kinds of laws will be necessary to regulate space flight? What conditions will exist for the sharing of facilities?

Student reaction to these questions will necessarily be based upon substantive research. However, they will also require the student to make some value judgments.

Research the seat of sovereign power at the time of the Articles of Confederation and the formation of the Federal Government. Why was there a change in form of government?

Make a chart showing the specific powers surrendered by states and the reasons for putting these powers in the hands of the Federal Government.

What kinds of powers were given to the Federal Government to prevent future problems?

What kinds of powers were given to the Federal Government to solve existing problems?

The above exercise should lead to the establishment of some criteria and the opportunity to develop some generalizations. For example: A centralization of authority necessitates a surrendering of some authority by participating parties.

From the study of the development of US government, formulate criteria that would be applicable to joint efforts in space.

The 17th and 18th centuries contain many examples of colonization. Select a country, i.e., Union of South Africa, India, Indonesia, and develop a trend for a shifting of the seat of sovereign power involving the period before colonization, during colonization, after freedom has been obtained. From your study, develop some generalizations that can serve as principles for future space colonizers. For example: Man has an innate desire to govern his own affairs.

From your generalizations, develop some rules/regulations/laws to govern space settlements.

Current research would indicate that there is no life on such planets as Venus and Mars; therefore, an attempt to draw a parallel with European attempts at colonization may not result in concrete examples. However, a parallel situation possibly exists when one compares space colonization to colonisation of Antarctica.

A. Research the agreements reached among participating nations in relation to the establishment of settlements on Antarctica.
B. Research the origin, nature of the agreements, and results of IGY.

REINFORCEMENT

Synthesize the approaches used in examples "A" and "B" above. From your research, develop a set of guidelines for nations participating in space exploration.

A. How would these agreements preserve national sovereignty?
B. How would these agreements impinge upon national sovereignty?

From your study of imperialism, assign weights to the leading countries involved in the race for colonies. One way would be to rank them separately on the following criteria: tonnage of commercial ships, total imports, total exports for a three-year period, number of ports open at least nine months of the year. The numerical positions on each scale could then be totaled to establish the weight for each country. This weight could correlate to the number of colonies owned by each country. From this data, one can derive an interesting correlation between the power of the mother country, the number of colonies, and its staying power in the colonies.

If we work with a solar map and view the planets as prospective colonies, we can apply the same weights to present-day countries except that we might want to add GNP to the power factor and hypothesize as to the number of planets that present-day nations might control and what their staying power might be.

If one holds to a cyclic view of history, then it is safe to assume that space colonization will lead to the same kinds of problems as did imperialism. The above exercise should help students get a better grasp of present-day problems, as well as an appreciation for the conflict between collective action and absolute sovereignty.

TOPIC 2.23
Scientific Discovery
ELEMENTARY CONCEPT SPIRALED: Scientific discovery affects the relationship of Man to the Universe.

SUB-TOPICS:

Technology
Discovery
Scientific Method
Interdependence
Universe
Vocation
Truth
Automation
Cybernation

This topic lends itself readily to either junior high school guidance courses or to vocationally oriented secondary classroom subject matter teachers. In this instance, practical application of scientific discoveries creates new vocations. These affect every intellectual and manipulative aptitude found in the school environ.

A multi-cross discipline approach can also be elected from this topic. Authorities in each academic area can be planned to re-enforce learnings in every other curricula offering in the school system. See, specifically, the concept of Scientific Discovery.

Generalizations about our Universe, or earthly home and our school environ, can be extended into the area of scientific discovery as a means of understanding reality. Quite capable secondary students might be led to explore the philosophical schools dealing with this concept and its impact upon mankind. A time study of major scientific laws, an intellectual discovery will be most rewarding in this area.

LEARNING ACTIVITIES

(10-12)

1. Time lines are fruitful in placing chronology to Man's scientific progress.
2. A research paper would be developed in conjunction with the Industrial Arts teachers on major application of a discovery to societal usage, such as Corningware.
3. A list of new electronic devices since 1950 would be quite revealing. This can be done in areas of home utensils, power tools, miniaturized radios etc.
4. Relative impact of technological discoveries would make interesting case studies. Faced with the horse, why did the Indians not develop a saddle similar to our Western saddle? This can be expanded into studies of the impact of an invention upon a nation's economy, i.e., industrialization, government spending, etc.

REINFORCEMENT

The concept of scientific discovery lends itself quite readily to a thematic approach to US history. It may highlight a flashback review of colonial times and Yankee ingenuity. Or, it may place the US inventors and scientific discoverers in the scope of world progress. Thus, it ties the US into the international scene in its early history. In secondary courses, this thematic approach can be utilized in tracing the tremendous industrialization of the US from the early 1830's to the present day. In this approach, sub-unit themes would be interchangeable parts, assembly line, mass production, automation/cybernation. The impetus that was and commercial competition give to scientific discovery can be indicated and placed in the perspective of adaptation of inventions to manufacturing processes.

In dealing with post-World War II events, great attention can be given to the choice aspects of an open society where we chose missile development rather than space exploration and thus were caught short by Sputnik. Again, choice in an open society has allowed us to "catch up" in many technological areas.

While the thematic approach allows us to focus upon the individual scientist, advances since Oliver and Wilbur Wright indicate the tremendous group contribution to technological discovery. The interdependence of physicists, mathematicians, engineers, and medical practitioners to achieve balance in our scientific discovery and its application should be forefront in the presentation to pupils.

Constant reference can be made to the place of scientific discovery in each of the following units in this curricula project. Economic, political, geographic, historical, scientific and industrial arts units will be discussing in detail many of the generalizations, skills, understandings and concepts which stem from the general area of discovery and its change impact upon Man and society. Here, especially, can the contribution of science to the better life be developed. A generalization about US science is that it has been utilized most specifically for its immediate or practical application rather than its pure or theoretical value.

LEARNING ACTIVITIES:

1. Using Newton's phrase regarding the "shoulders of giants", have pupils examine various scientific ages, the leading scientists in each age, and the "giants" that led to their successes. This research can be extended to show the "community of scientific research" which exists throughout the world rather than in an antiseptic laboratory. This activity lends itself readily to learning the scientific method as it is employed in the world of research. It also can be used in developing the skill of formulating generalizations and applying them to test their validity.
2. A case study can be made in which the time of adapting discoveries to the market place is developed. Make this a multi-discipline case study:
   a. Sewing machine to shoes.
   b. Heat resistance to "Corningware".
   c. Airplane to jet age.
3. Another case study could show the pyramidal effects of an invention upon other products, i.e., airplane, parachute, radar, air ships, radio contact, etc.

TIE ACTIVITY TO INDUSTRIAL ARTS AREA. See activity under "Location and Globalism" on launch sites for an inductive approach to problems of scientific adaptation.

TOPIC 2.24

LOCATION AND GLOBALISM

ELEMENTARY CONCEPT SPIRALED: Every time a classroom teacher pulls down the wall map, she is in a position to begin teaching problem-solving and interpretative techniques to the class. A map is a graphic representation showing a distribution or distributions of phenomena across a surface. These distributions may or may not be in close association with each other. It is the interpretations of groups of points arranged in distribution, viewed in association that gives the map its unique place in education. The map presents data in a form that is not entirely verbal and not entirely pictorial. Unfortunately, many social studies teachers overlook the tremendous potential of map work that lies beyond identifying point or place locations. It will continue as a highly defensible and effective teaching tool in dealing with space and planets we explore.

LEARNING ACTIVITIES

(10-12)

1. Identify the special nature of area of interest that is attributed to a place location, i.e., Paris is a city of seven million people. It is also a capital city, an art center, a manufacturing center, a fashion innovator, and so on. Isolate that which is to receive focus in the map making, map reading, or map interpretation.

   For this activity, let us choose launch sites (locations) of small meteorological rockets, i.e., while Hawaii is the location of many things, we are going to consider it here only as a location of a small rocket launching site.
2. Build a distribution (use pins, grease crayons, or mylar overlay) of similar locations. (These would be other points which while otherwise different share the criteria of investigation.) In this case, note the location of other sites of small meteorological rockets such as the following:
   a. Eniwetok, Marshall Islands
   b. Hawaii
   c. Point Barrow, Alaska
   d. Fort Greely, Alaska
   e. Point Mugu, California
   f. Tonopali
   g. White Sands, New Mexico
   h. Ascension Island (South Atlantic)
   i. Bermuda
   j. Wallops Island
   k. Fort Churchill, Hudson Bay, Ontario, Canada
   l. Patrick Air Force Base, Florida
   m. Elgin Air Force Base, Illinois
   n. McMurdo Sound, Antarctica.
3. Attempt to build some associations between the distribution portrayed and other distributions of unlike origin. Ask the class to "see" what appears as a common denomination in the location of small rocket sites. This step implies that questions will be raised by students and teachers alike. Are you involving the class in an inductive quest for rationale explainer of why things are where they are and not simply the fact that they are there?

Some possible associations are:

a. Rocket launch sites and the Northern Hemisphere.
b. Rocket launch sites and proximity to the coastline.
c. Rocket launch sites and proximity to large bodies of water.
d. Rocket launch sites and areas of sparse population.
e. Rocket launch sites and the periphery of U.S. territory (McMurdo Sound in U.S. territory).

What other associations can the class offer? Build a list of these on the chalkboard and carry on an inductive dialogue designed to reach the final step of map interpretation, arriving at a generalization.

The criteria of location changes due to changes in the technological skills of the culture. In this sense, while points or places have a mathematical location expressed in terms of latitude and longitude coordinates, they also have a relative location.

Relative location is a useful concept in explaining why some locations become important. A location is only valuable in relation to or in interaction with other points or locations. The following case is such an example:

a. Before the invention of aircraft, Gander in Newfoundland was a location of relative unimportance.
b. After the practicability of transoceanic propeller commercial aviation, Gander's location took on economic and strategic importance.
   (1) Re-enforced the Great Circle Route notion.
   (2) Gander, an important refueling link for the Ferry Command during World War II.
c. With the advent of the big jets, the necessity of refueling stop at Gander diminished and the air base declined in its economic and strategic importance.

Gander, as a location, can therefore be examined in relation to various eras of transportation. Have the class list places of economic or strategic importance in the world today, i.e., Sault St. Marie, Panama Canal, Volga-Don Canal, etc. Where these locations always of equal importance? What changes in our cultural attitudes or technology effected the relative location of these places?

List locations that were of great historic importance, but have since declined, i.e., Timbuktu (with decline of caravan methods of trade), Khyber, Venice, etc. Turn the attention of the class to the cause of the decline. For example, Venice on the east coast of the Italian Peninsula faced the east and acted as the terminal and distribution point for the sea-land route to the Middle East, India, and the Orient. With the advent of the sea route to India (de Gama), Venice entered a decline while cities like Genoa, Florence, etc., on the west coast began an ascendancy.

The development of a great steel-clad, steam-driven fleet by the UK, the US and the other great powers in the latter part of the 19th century and the early 20th century required the establishment of strategically placed coaling stations. Remote islands and harbors took on importance. Later, when coal and steam became obsolete, certain naval bases survived and grew into major naval air bases and even commercial ports. Pearl Harbor is a good example. While industry and tourism are large parts of the increase of our 50th state, the single biggest contribution is the US Navy.

What locations in the solar system will become important to space activities? What elevations and orbits are key points for docking procedures? With changes in space technology, will there be resultant changes in the relative locations of points in space?

REINFORCEMENT

Here is an inductive and open-ended activity for the clas based on the location of "inner space activities". Ocean science and space science are now providing challenging frontiers to our society.

1. The task of the class is, with the aid of data, maps, etc., to find a suitable location for an oceanographic laboratory relative to the following fourteen (14) criteria:

a. A port adjacent to deep water where up to five seagoing ships can be safely berthed with a minimum of 25 feet of water at the dockside. A minimum of one thousand lineal feet of dock space with the possibility of expanding to two thousand feet;
b. Availability of approximately 350 thousand square feet of land adjacent to dockside;
c. Proximity to the ocean;
d. Feasibility of year-round operation;
e. Proximity to academic institutions with demonstrated interest and capability in mounting programs in the physical sciences;
f. Availability of other "marine oriented" scientific activities;
g. Existence of other research activities;
h. Availability of good internal and external transportation and communication facilities;
i. Availability of supplies and equipment for outfitting ships for long voyages;

j. Proximity to adequate shipyard and ship repair facilities;
k. Availability to adequate manpower pools with staffing ships' crews;
l. Suitable living conditions for personnel of all economic levels, including reasonable living costs for families of ships' crews;
m. Relative costs of site and equipment maintenance in operations, including maintenance dredging;
n. Availability of Federal, state or private land and improvement.

2. Compare the list of the "best locations" supplied by the class, with the generalization. Do they fit?
3. When several sites appear of equal importance, how might the problem be resolved?
4. Have the class choose the best locations for launching sites. Assuming that Cape Kennedy will not remain our only major space launch site, what other locations loom as having great relative advantage? The class will have to develop a list of criteria (similar to the Ocean Laboratory) with which to measure each "candidate location". To spur the discovery process on, mention that the present launch site is on a peninsula with a launch path that takes it over a body of water for safety. Recovery is also made in the hydrosphere. Assume a change in technology that enables the space capsule to be recovered on the lithosphere. Will Cape Kennedy then lose its importance as a launch site. (Note: Soviet launch site as in Kazankstan and the Red Chinese site is near Lop Nor in the Sinkainy Depression--both deep in the interior of the world's largest land mass.)
5. To stimulate the class development of locative criteria, give the youngsters a few instances: safety; remote, yet accessible for materials and parts; cloudless skies for ease in tracking the launch for the initial several seconds after lift-off and so on.

Possibly no location would match the "ideal". Note that while Cape Kennedy is in a good location to launch vehicles down the Atlantic Slot (On a polar map projection, this appears as a straight line from Cape Kennedy to the area of Ascension Island. The Atlantic Fusing Range appears as the Oceanic slot between the African and South American land mass. The mercator projection, where lines of latitude and longitude form right angles, distorts this concept. On this projection, the great commercial sea lanes of the North Atlantic are hundreds and even thousands of miles away and moving off at right angles to the launch path.)

Cape Kennedy, however, is in the transition area between a humid continental climate and a subtropical climate. One of the hallmarks of a sub-tropical climate is that an increased percentage of the sky is in cloud cover. This is a decided disadvantage to launches and has resulted in many "holds".
6. Activities on relative location can be applied to the Supersonic Transport. What cities will blossom because they have the room to accommodate the SST? What other cities, now receiving jets and still others only handling conventional aircraft, will decline in importance as airline terminals?

Stressing and re-enforcing the following will aid in developing the students' global perspective:

Why is it easier to get a sunburn in Florida in January than it is in Massachusetts?
Approximately how many miles north of the equator is your community?
Why is the length of longitudinal degrees not always equal to the 70-mile approximation?
Can you think of any occupations where a knowledge of latitude, longitude, and earth-sun relations are a must?
How many time zones has the US? How many does the USSR have? (a good contrasting device for relative size)
Why is New York's time ahead of Seattle's?
Why does the International Date Line not follow exactly the 180th meridian?
Why does 15 degrees of longitude equal one hour of time?

TOPIC 2.25

INTERDEPENDENCE-INTERACTION.

ELEMENTARY CONCEPT SPIRALED: People of the world live together, not independently of one another. In a speech at Yale University, President Kennedy called for a "Declaration of Interdependence". Independence seems to be a concept that is both well taught and well understood by our US school children. The thread of independence runs throughout our history and throughout our economics, political and social lives. In business, we desire independence from interfering governmental controls: in our homes, we expect to be free from any invasion of our privacy by citizens or authorities alike. Interdependence

is a concept that, on the surface, appears alien to the US way of life. At first thought, to depend upon others is taken to be a sign of weakness. Is not the US blessed with the natural resources that make us self-sufficient? While the answer to that question a few years ago was yes, today it is a definite no. We depend upon others for some of the raw materials for our soaring technological society. Space efforts may very well increase our diplomatic complications for this reason, or, conversely, diplomatic relations may pace our space accomplishments.

LEARNING ACTIVITIES

(10-12)

The following activities will demonstrate to the class some of the ways in which the US society depends upon and interacts with other peoples on our planet.

Use an economic atlas for reference (Oxford Economic Atlas).

1. The US depends upon outside sources for nickel, an important ingredient in metallurgy. Locate the world's major sources of nickel. Hypothesize, given our steel-making complex located on Lake Michigan's south shore, follow the source and routes of flow of this metal to the point of fabrication. Repeat the same for the following: chromium, bauxite (aluminum), copper, industrial diamonds, and pitchblende.
2. Have the students research the importance of each item for our industrial capacity. For example: Copper, because of its ductility and other qualities, is a basic metal in the electrical sector of our economy and the entire space program. US copper interests have been concerned about the depletion of our copper reserves in Montana and Idaho. While iron ceases to become an ore at about 25% content, copper can be mined from parent rock material with about 1% copper content. New approaches to metallurgy and mining technology have resulted in the efficient use of low-grade taconite (for jasper) in our iron and steel industry through a process called beneficiation. This process has saved the Lake Superior iron towns from entering ghost town status. But copper has pushed efficiency to the nth degree (1% ore content) and still there are shortages.

REINFORCEMENT

1. Zambia has a rich copperbelt that runs across the border into Katanga province of the Congo. The Zambesi River forms the border between Zambia (Black rule) and Rhodesia (White rule). In fact, the first people to issue a Declaration of Independence since the Americas did in 1776 and against the same Mother country. The Kariba Dam provides hydroelectric power to the mining interests (European-controlled) of Zambia and the industries of Rhodesia.

Present the incredible complexity confronting the Americans as they perceive this problem, i.e., need for copper, desire to remain free of African entanglements, desire that vital raw materials not come under Communist control, pressed to please sanctions on a country that did (Declaration of Independence) what we did, by an ally that was once the recipient of our own Declaration of Independence. The domestic pressure at home from racist and civil rights leaders as they interpret the state of affairs in South Africa and our own role in the UN as a gardian of world peace. To say that we are interdependent and interact on many levels with distant portions of the earth is almost an understatement.

2. The copper case can be pushed further. Have the class consider the Chilean deposits being worked by Anaconda. Could this have any bearing on the heavy attention given in our press to the stability of the government of Chile, its elections, and the direction articulated by governmental leadership? Is there justification for the thought that successful space exploration may in fact depend more on the backward or developing countries (in a supply sense) than on our own technological prowess?

TOPIC 2.26

WEATHER

ELEMENTARY CONCEPT SPIRALED: Weather plays an important role in Man's life. As Man's culture involutes or "progresses", he gains greater control over his environment. This increasing control can result in exemplary or unfortunate consequences, i.e., air pollution vs. Tiros weather forecasts. While modern Western man has greater knowledge about predicting weather (he does not engage in Rain Dances), his reverses are more costly at the vagueness of weather.

To progress is to become dependent upon our machines. The experience of the great blackout a few years ago is a case in point. The inconvenience, fear, disruption of activity (economic and social) experienced by the people in the US was a general outpouring of a demand for an investigation of, "What happened?" The motif of life for several hours was deaccelerated. Yet the blackness that engulfed our land is the fact of Asia every evening. To progress is to suffer severe reverses in those cases where Man suffers a loss.

LEARNING ACTIVITIES

(10-12)

1. Once upon a time, attitude toward weather was just about unanimous. In an agrarian culture, the need and desire for rain might be mutually shared at any given time. In a society affected by the Industrial Revolution, the need and desire for rain would vary greatly. "Good" weather and "bad" weather are not universals, but relative to the division of labor and regional specialization of a culture. Have the class create classes of industry and then sub-

classes and activities within the industry. Have them postulate what each occupation (cultural term) would consider "ideal" weather to be. Note the conflict of weather attitudes not only between industrial classes, but within the same sub-class (golf and ski). For example:

Industrial Class	Sub-Class	Activities
Service-oriented	Recreation	Golf course

2. Have the class pursue the progress of our culture from weather superstitions (this in itself is an interesting activity) to accurate weather prediction, and extrapolate to some degree of weather and climate control. What kind of national or international agency would have to oversee the kinds of weather to be induced? Consider the implications of the following cases:

a. Cloud seeding is a form of weather modification. Some of our arid states are located in the belt of the prevailing westerly winds. If water poor states (X) located directly west of water poor states (Y) engage in "seeding", this diminishes the amount of moisture available to States Y that would have occurred under natural circumstances. What happens? Will the Supreme Court be involved? Will an agency have to be set up to regulate recurring problems of this type? What are the ramifications of weather control? Food surpluses have always been important to civilization. Even military groups throughout history have attempted to overcome the logistics of keeping their marching armies fed. This notion was articulated by Napoleon in his "an army travels on its stomach" statement. In this context, the process of canning, freezing, and dehydrating food is an exertion of man's control over his weather. The harvest of a prior year bumper crop can be consumed in a year that may have suffered crop catastrophe.

3. For an interesting open-ended discussion, have the class correlate the bellicose and sword-rattling attitude of Red China with their harvests and weather patterns. In periods of poor weather and harvests, what changes are there, if any, in the hard line? Caution the youngsters that this kind of weather-man relationship is a dangerous game to play if other variables are ignored. Can one actually say that in periods of bad weather, poor harvests and low or no food surpluses, nations tend to become less aggressive? This, of course, is an over-simplification of cause-effect relationships. To have the youngsters understand the myriad of variables entering the equation, pursue the following activity within your school.

REINFORCEMENT

1. Keep a daily log of the weather conditions for a prolonged period (30 days). Enlist the aid of the school administration for the same period by having them supply data to you on the number of discipline cases offered each day. Keep comparative graphs of the number of discipline cases and weather conditions. Is there any correlation? To what variable is there any correlation (time of day, temperature, pressure, wind velocity, etc.)?

2. The object of this activity is to show the great danger in making an over-simplification of cause-effect statements between man and physical phenomena. The FBI ANNUAL REPORT OF CRIME is a case in point. Crime goes up during the warmer weather. Beaches are locations of high crime incidence. Is crime a result of animal-responding to weather and weather type activities, or is it one of criminals going to locations that are crowded? In a period when our society did not have the ability to get to beaches in such great numbers, were crime rates as high there? High crime rates can be found in rail and plane terminals and other places where large numbers of a transient group is in close proximity to each other. The variables can be added to. For example, the FBI source shows that Chinese-Americans have a remarkably low crime rate irrespective of weather or location.

3. The class can suggest many apparent correlations between weather and man. As the class guide, you should be alert to show how man-made or social complications distort what appears to be simple cause-effect relationships.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Neph-Analysis Facsimile charts available from airline dispatch offices.

EP-6 Space, the New Frontier
EP-27 Meteorological Satellites

Films:

"Keeping an Eye on Ginny," 1965, NASA HQK126, sound-black & white, 27 min.
"Tiros: Experimental Weather Satellite RCA," 1961, NASA HQA 25, sound-color, 14 min.
"Tiros II: Experimental Weather Satellite RCA," 1961, NASA HQA 31, sound-color, 6 min.
"Trial Balance," 1965, NASA HQ 123, sound-color, 25 min.

TOPIC 2.27

MAN and ENVIRONMENT (Insolation)

ELEMENTARY CONCEPT SPIRALED: Our surroundings have a direct relationship to scientific discovery. We will live differently 50 years from now because of Space Age discoveries. Note that this topic is spelled with an "O". It is not insulation, but insolation. Insolation refers to incoming solar radiation. The way in which the rays of the sun strike the earth greatly impinge on our life and way of living. The transfer of incoming solar energy into plant food and fiber is the basic concept of understanding life on our planet.

LEARNING ACTIVITIES

(10-12)

1. To gain a statistical picture of the significance of insolation, consider the role of the hog in human economics: the hog is a vehicle for changing insolation to protein. No other animal changes the sun's rays to meat so

effectively. Fourteen (14) pounds of sun will produce two pounds of hog; two pounds of hog result in one pound of edible pork. Such is the most efficient equation known to man for converting "Old Sol" into animal protein. Is it any wonder that one of the most profitable economics of our planet (the corn belt of Iowa, Illinois and Indiana) is based on corn-hog production.

2. With the aid of a flashlight and the classroom glove, demonstrate that insolation in the high latitudes covers a greater area of the earth. The amount of heat in the sunlight is the same as received at the equator. However, it is distributed over a wider area. The spherical nature of the earth is as important as insolation in understanding the heat differentials and climates of the earth.

INSOLATION

3. Pose this question to the class. If the oceans represent base or sea levels, why are there ocean currents? Why do the warm currents flow northerly and cold currents flow southerly (in the Northern Hemisphere)?

4. Stress the notion that while some very often adapt to their environment, modern man modifies his surroundings to a great extent. Have the class compare the cultures of the Yakuts (Siberia) and the Fuegans (Tierra del Fuego). How have these peoples adapted to and modified a restrictive environment? How do both differ from the Eskimo of Baffin Island?

5. Several decades ago, a prominent geographer, Ellsworth Huntington, wrote a book entitled CLIMATE AND AIR. In it, he presented the hypothesis that there was a causal relationship between climate and civilization. The ideal climate for the stimulation of human vigor, mental and physical, was held to be those of the middle latitudes. Today many professional geographers have taken exception to some of Huntington's notions of environmental determinisms. Some geographers have even moved to proclaim that we are in the age of cultural determinism; man is the great modifier of the natural surroundings. Research and case studies presented by class members on both sides of the fence may serve to clear the air and place both man and climate in some kind of ecological perspective.

6. The classification system of climates could be presented to the class. One hint, however, is that instead of presenting this in a descriptive way, use be made of climate graphs. Stations and data can be shown which are representative of their respective Koeppen climates.

1. Have the students make a graph or place an overhead projector for class analysis.

The four basic notions to stress in dealing with earth-sun relations are:

a. Inclination - the earth's axis is canted at 23-1/2° angle off the perpendicular.
b. Rotation - the earth revolves on its axis.
c. Revolution - the earth revolves about the sun in an elliptical orbit.
d. Parallelism - the axis of the earth always remains parallel.

With these building blocks, the relationship of earth-sun and climate can be developed. For example, place these terms as captions in a chart. Have the class place all other terms tied to earth-sun relation under the phenomena that is responsible for its existence. Classroom demonstration and student manipulation of the globe will be needed to fully develop these understandings. The following chart suggests what such a chart might look like.

The Four Basic Earth-Sun Relationships

Inclination	Rotation	Revolution	Parallelism
six months of daylight, etc., at either pole	day/night	solar year	six months of daylight, etc., at either pole
seasons	Coreolis effect		seasons
north and south			north and south
inverse seasons			inverse seasons

Based on this activity, have the class extrapolate the application of these four concepts upon the environments man will modify or react to on the planets of our solar system. Each student could be assigned a planetary ecological system to report on.

Prepare a list of typical climatic stations based upon the Koeppen system. Insert a climograph for duplication on the overhead. Have class deduce where such a station might be located.

2. This map pinpoints places, dates, and data of climatic extremes of our planet. What factors are important to keep in mind the differences that occur in environmental phenomena from place to place across the earth's surface? With the aid of atlases, physical wall maps and globes, let the youngsters hypothesize the environmental factors that would be prevalent in each or several of the instances. For example, why is Cherrapunji the rainiest spot on the earth? What environmental factors combine at this place to bring about such a phenomenal annual rainfall?

3. Do not waste a great deal of time teaching the facts of these locations. Stress rather the processes that interact. Below are seven environmental impacts that, to a greater or less degree, explain the climate of a particular area:

Environmental Impacts

a. Latitude
b. Altitude
c. Mountains as barriers
d. Prevailing winds
e. Cyclonic storms
f. Semi-permanent highs and lows
g. Ocean currents

Example: Antarctica
High Lats. - oblique rays of sun
High rise reaches 9,000 feet (therefore, temperature color North Pole, which is a water pole)

4. Have the class suggest a list of place names and put them on the chalkboard. As a motivational technique, suggest real places that have a distant, romantic aurora about them, i.e., Timbuktu. With the help of maps, globes, atlases and other sources, place beside each location a series of environmental impacts that greatly explain the climate of that place.

5. Take the class list (or those supplied in this guide) of environmental impacts and apply them to the planets of our solar system. For example:

a. All planets of our solar system intercept certain amounts of insolation.
b. All the planets are spheroids.
c. Because of this, all planets have latitude. Hence, certain portions will be less hostile than others.

Unit Review

Earth-Sun Relations	Climatic Controls	Affect	Produces
a. Revolution around the sun	a. Sun (latitude lines	a. Temperature	a. Various types of weather
b. Rotation on axis	b. Distribution of land and water bodies	b. Precipitation and humidity	b. Hence, Climate (the aggregate of weather averaged out)
c. Inclination of axis	c. Ocean currents (warm or cold)	c. Air pressure	
d. Parallelisms of axis	d. Elevation (altitude)	d. Winds	
	e. Mountains as barriers		
	f. Semi-permanent high and low pressure areas		
	g. Storms (type: cyclonic, etc.)		

3. Fine Arts

by Leon Wirtenberg
Patricia Z. Wirtenberg

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Fine Arts

INTRODUCTION

Man Adapts: Stone Age to Space Age

Today, man struggles - as he did in the time of the cave dwellers-to satisfy his need to understand himself, to understand his environment, to adapt to it, and function in it.

If he is a scientist, he observes and then speculates about his observations, searching for the common factors and the relationships which connect the phenomena in which he is immersed. He seeks to express in a simple thought, and so make visible, the invisible underlying order, the organizing and unifying quality in nature. Thus, he explains his world to himself and it is no longer a frightening madness.

If he is an artist, his struggle is the same. His aim is the same. He seeks to express in a simple "thought", or image, the order, the unifying harmony which underlies his perception of life around him. He too strives to explain his world to himself so that he can live in it, not as a soulless animal, but as a man.

Whether he is an artist or a scientist, a man's struggle to relate himself to his world is most painful during a period of rapid change. Such a period is occurring now, with our technological world exploding out toward an endless universe and imploding in toward an internal infinity. Man's tested relationships, his trusted intuitions, his symbols, all his explanations must at the very least be tested anew against the enlarged challenge of never-before-recorded phenomena and never-before-felt experience.

He must produce new acts of both scientific and artistic creativity, new visions of a broader, more inclusive harmony, and new expressions of a steadier, greater truth.

In this way, man will again test how far he can travel from the cave, how far he can modify his own environment or move into a new environment and still function. His survival as a man will depend on the accuracy of his perceptions about his new environment. His scientific perceptions, expressed in the rational language of technology and logic, must be accurate for his physical survival. His artistic perceptions, expressed in the intuitive language of imagery and feeling, will make possible his psychic survival.

NASA Leads Man into Space

NASA is an explorer and a researcher. From its Earth-bound base it sends out manned and unmanned aeronautic and space expeditions in airplanes, rockets, orbiting, satellites and space vehicles.

It studies the environment of near-space, the region directly affected by our Earth, with its gravitational and electromagnetic fields, and its atmosphere. It reaches farther out from our planet toward our natural satellite, the moon, with the series of projects culminating in the Apollo manned lunar landing. It probes still farther into our solar system with planetary, interplanetary, and solar-orbiting missions.

We gather new information during these explorations by the tracking and measurement activities at Earth stations, by the reports of returning pilots and astronauts, by the instument recordings and sample gatherings on payloads which return to Earth, and by the monitoring of telemetry signals from instrument packages sent irretrievably into space. Some signals are unravelled and reorganized by computer, resulting in high-resolution photographs.

Confronted with this new information, we are forced to reexamine some of our Earth-bound ideas. Some long established "facts" about the earth itself are shaken. What is its actual shape? What is the true distance between points on its surface? How thick is its atmosphere? Some of our concepts about the universe, and the Earth's significance in that universe, are exposed for fresh examination. What do we mean today by a "long distance"? Is it how far you can walk before you're tired, or is it how far a space vehicle can go before its communication signals are too weak for us to receive? What do we mean by a "long time"? Is it the whole lifetime of a man on Earth, or is it the lifetime of Earth in the Solar System? Or is that too but an instant?

What do we expect to convey by using the color "blue"? Is that the color of the sky? No, the sky is really black, in space. Is it the color of the seas? No, the seas are dark gray, from space. What do we mean today by "blue"?

Man has reexamined his ideas and his feelings about his environment ever since he first learned that fire could conquer cold as well as destroy. He adapted his ideas, slowly, by developing ways to control and use the fire he once feared, and he adapted his feelings as the thing he had feared become his friend.

Now, Man and his machines have ventured to conquer the cold, forbidding, almost-void of space. Properly prepared with equipment and training, Man has not been destroyed, but has successfully explored, and returned to Earth. Thus the NASA experience leads us out into the universe with new observations, new answers, and new questions. Once again, not only our sciences, but our psyches have some adapting to do.

Fine Arts in a Space-Oriented World

How can our Earth-born children meet the space-borne challenge to the irrational, "feeling" part of their human nature? How will they develop the intuitive judgments that will guide their day-to-day lives? Our old Earth-oriented symbolism for communication, our fundamental perceptive orientation, our visual language has been muddled by both the new technology we are creating from our space experience and the new relationships we are learning from our space observation. How then can we explore, adapt, relate, and explain ourselves in the space-oriented world? Where, within the organized, rationalized, computerized endeavor that NASA is and must be, can we find the esthetic-emotional expression of Man?

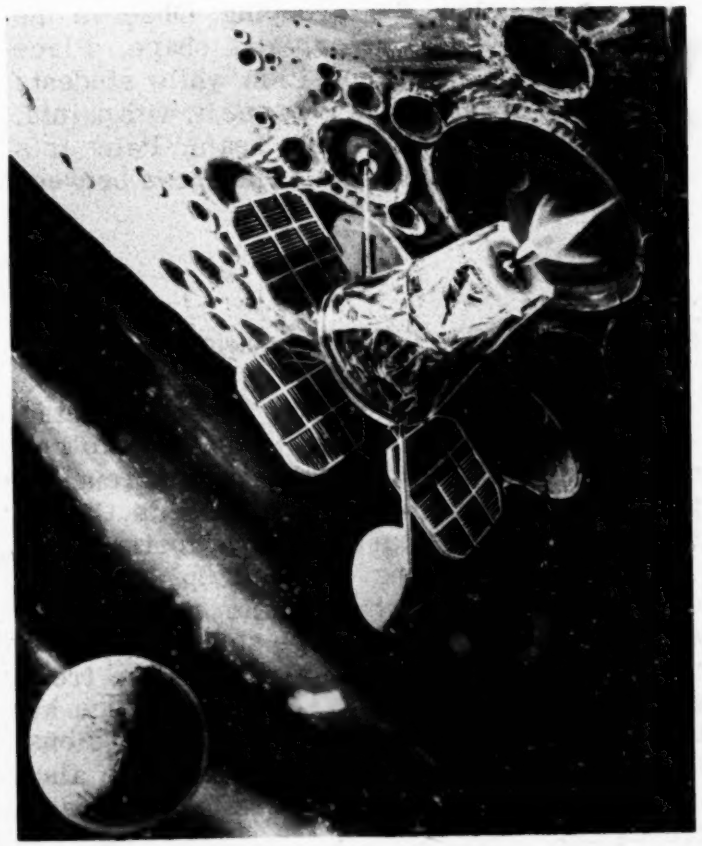
Art Education can address itself to this problem. By drawing on the NASA experience, it can offer a new enriching expansion of awareness to the developing child in terms of the new world of space exploration. It can offer educational activities that build on his enthusiasm and his interest in this new environment. It can focus his perceptions and consciousness onto visual stimulations and physical experiences that men only imagined just a short time ago. It can project his imagination forward into sensations and situations which are just a short time ahead. It can help the growing child to relate his total self, with his whole sensitivity, to the exciting worlds in which he will live.

TOPIC 3.01

Space Environment: Matter in the Void

Space is a vast cold void, a nothingness, once we move beyond the earth's atmosphere. Yet it can also be said to be filled with matter, with billions and billions of bodies from dust-size to giant stars and great galaxies; with comets, planets, asteroids and meteroids; and with satellites, natural and man-made. The great number of stars (or "suns") suggests the probability that there are other solar systems with planets like ours. Vehicles like the Pioneer space probes which first explored the interplanetary regions of our solar system may one day explore other solar systems.

Lunar Orbiter



LEARNING ACTIVITIES

(K-3)

1. Look at a picture of a perfectly flat salt desert. Look at a picture of a desert of sand dunes. Look at a picture of barren, rocky earth, with just one or two trees. Discuss the following:
   a. Which is the most empty looking, and most lonely looking?
   b. Why does "adding just a little" make a completely empty space feel even more lonely, more empty?
2. Paint a picture of a lonely space. Then add just enough so that it doesn't seem lonely or empty anymore.

(4-6),(7-9),(10-12)

1. Gather a variety of small, simple objects (such as checkers, marbles, buttons, pebbles, and jig-saw puzzle pieces). Choose one type of object at first. Select a neutral tone or black paper 9" x 12". Consider this area as a portion of interplanetary space. Place several pieces of this material you have chosen on this background to create a pleasing arrangement. Discuss the following:
   a. What are your feelings about other students' arrangements?
   b. Remove some of the pieces.
   c. Can you leave the remainder untouched and still feel it is a pleasing arrangement?
   d. Is the 9" x 12" area too empty? Or is the arrangement perhaps more pleasing than it was before?
2. Replace all the pieces you took away...now add as many new pieces as you originally had in your interplanetary space. Discuss:
   a. Can you still make a pleasing arrangement or is it too crowded?
   b. What is the right amount of matter to fill the 9" x 12" void so that it is not too crowded?

TOPIC 3.02

Space Environment: Color, Darkness, Light

The atmosphere around our earth is constantly in motion and almost always cloud filled. As we on earth look up, it scatters and shimmers the light of the sun. Once in space, unless we are looking very close to the sun, the sky appears a solid steady black, studded with brilliant stars which never twinkle. The colors and surface patterns of a planet, derived from the reflected light of the sun, inform fly-past spacecraft like Mariner about the planet's surface characteristics.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Collect samples of black things (cloth, paper, painted metal pieces, leather, wood, yarn, ink, fur, pottery). Place them close together on a table. Discuss:
   a. Why don't they disappear against each other?
   b. Which piece is blackest?
   c. What is the color black?
2. Create some pictures (collages) using these materials on a black background. Suggested titles: "Moonscape at Night" (without sunlight)"; "Space Vehicles Rendezvous at Night"; "The Quiet of Outer Space", Shine a blue light on the completed collages. Discuss:
   a. How does this light affect your collage?
   b. Does it intensify or diminish textural surfaces?
   c. Does it help or hinder your ability to distinguish the different pieces? Add a few small, white buttons to your collage.
   d. How does this addition affect your ability to distinguish among the black pieces?

(10-12)

1. Select a variety of simple, painted objects (such as spheres, cylinders, boxes with projections). Group these together in a pleasing arrangement. Project a beam of light from flashlight or spotlight onto the grouping. Slowly move light source around the grouping, and above and below the grouping. Observe the changes of value, color, and shape. Place beam in a stationary position while students record the grouping, as they see it, with paints. Change the position of the beam. Paint this new version. Discuss the differences between the two paintings.

TOPIC 3.03

Space Environment: Radiation Emissions and "Wind"

The emission of X-rays from the sun is being studied by NASA projects, in addition to research on gamma radiation in space and energy particles in the famous Van Allen belts. Orbiting Solar Observatories carry instruments which count neutrons bounced up from the earth's atmosphere by cosmic rays. Radio emissions from the sun are studied by separating them from the loud radio noise from sources in certain distant galaxies, such as the Crab Nebula. The hot plasma emissions from the sun (the solar "winds") are also being studied for their possible effects on space travelers.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Observe the way water flows around an object (water in a stony brook, or rain in the street).
2. Compare this to the pattern of solar wind or plasma around the earth.
3. Draw on tracing paper the pattern of this flow. Draw the pattern of waves from a pebble dropped in a pond. Is this any different from the way radio waves come out from a radio star?
4. Superimpose the two patterns; add other patterns of flow and radiation to create a representation of the many different invisible wave phenomena that can occur in space. Some of these phenomena are helpful and some are dangerous.
5. Retrace your patterns using different colors to express your feelings about the harmful or helpful phenomena.

(10-12)

1. Although they are invisible, neutrons can be "seen" by the path they leave behind as they pass through a specially designed chamber. This is like following the path of a raccoon through a wheat field by the movement of the wheat. Give other examples of things we "see" by their effects. Draw the trail that a rocket has left as it traveled into the sky. Do not draw the rocket. Consider the effects of the wind at different altitudes.

TOPIC 3.04

Space Environment: Gravity and Magnetism

The gravitational pull of one heavenly body on any other - including the pull on a spacecraft- is related to its mass and how that mass is shaped. The accurate plotting of satellite orbits has already revised our ideas about the shape of the earth and the distribution of its mass. Something close to a pear shape is required to explain the gravitational pull on orbiting objects. Our understanding of the shape of the magnetic fields of the Earth and the Moon has been revised by studies from satellites and lunar vehicles.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Experiment with magnets and metal filings. Scatter gray iron filings onto a smooth sheet of opaque plastic. Move magnet around under the plastic. Move several magnets under the plastic at the same time. Move one magnet while another remains stationary. Introduce bits of colored metal and metal filings into or near the gray filings. Move the colored pieces around, without touching them, by moving the magnets below the plastic sheet. Create a pleasing pattern. Introduce several large magnetic and non-magnetic objects onto the plastic sheet, and move the filings around them, using the magnets from below. What is the difference in the patterns created?

(10-12)

1. Conduct an investigation of contemporary sculpture which uses the phenomena of gravity and magnetism, especially those which are kinetic, or moving, sculpture. How do some work with the forces of gravity and how do some oppose it? List the ways in which the sculptors create motion, or maintain it, in their sculptures. What sources of magnetism are used?

TOPIC 3.05

Space Environment: Distance and Time

In addition to space probes, NASA plans to launch Orbiting Astronomical Observatories to study stellar radiations, the tenuous interstellar gas between the stars and the emissions from far-distant galaxies. Considering that the very nearest star (Alpha Centauri, actually two stars revolving about each other) is so far away that its light takes four years to reach us, the OAO will observe into distances that can overwhelm the imagination. It is probable that we will be able to see into the universe to a distance of 2 billion light years...or farther!

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. On our own planet, we are never aware that light takes time to travel from one place to another, because it travels so swiftly. But the stars are so far away that the light that leaves the star and travels to us at 186,000 miles per second can take as little as four years or as much as 2 billion years to reach us. Therefore, when we look at a star we actually "see" the star as it was many years ago. It is as if different times in history were happening at the same time.
   a. Paint a picture that shows people from different periods in history all living together at the same time.
   b. Include also "people of the future" in your picture.

(10-12)

1. Draw a series of five pictures of the Moon as a space traveler would see it:
   a. From the vicinity of the sun
   b. As he approaches the Earth
   c. From the Earth
   d. As he approaches the Moon from the Earth

TOPIC 3.06

Space Vehicles: Launching

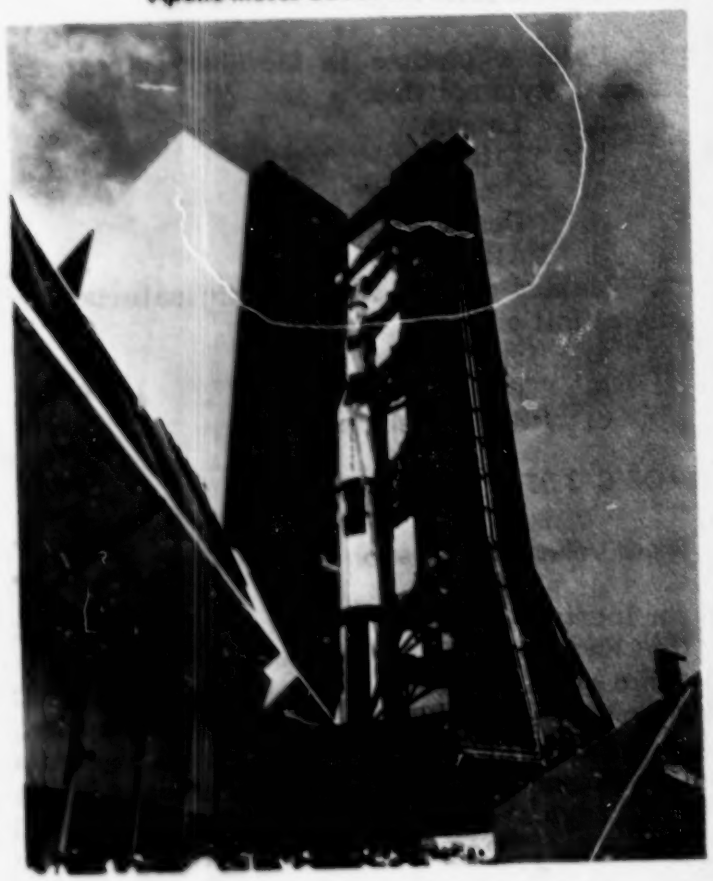
Since the Atlas rocket boosted the first United States manned satellite into orbit, steady NASA developments have led to the Saturn V design, a spacelaunch vehicle which stands 350 feet high. A cluster of five engines in its first stage, developing a total of 7,500,000 pounds of thrust, will lift off approximately six million pounds. Thus, in these few years, an increase of more than twenty times in launch capability has been achieved.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Paint a picture of a launch pad as a rocket is being prepared for launch, showing the personnel and the equipment involved.

Apollo Moves Out of Vertical Assembly Building



2. Paint a picture of the rocket at moment of liftoff, as seen from directly above. Paint a picture of a rocket a few seconds after liftoff as seen from the launch pad directly below it.
3. Paint a picture of a launch pad shortly after liftoff, without showing any part of the rocket, so that your picture emphasizes the flame, steam, dust, and smoke behind the rocket engine.
4. Paint a picture of a launch as seen from several miles away on a day when weather conditions have almost prevented the launch.
5. Paint a picture of an unsuccessful launch, which ends in the controlled destruction of the rocket at a safe height above earth.

(10-12)

1. Paint a picture in the abstract expressionist style entitled:
   a. "Launch"
   b. "Liftoff"
   c. "Countdown"
   d. "Destruct!"
   e. "All Systems Go!"
2. Make a collage, using plastic materials and metal foil entitled:
   a. "Saturn"
   b. "Booster Separation"
   c. "Space Debris"

TOPIC 3.07

Space Vehicles: Navigation and Guidance

An inertial guidance system is independent of the Earth, unlike a magnetic compass or a radio guidance beam. It establishes three fixed reference directions, sets a course direction, and detects any changes in motion away from the planned course direction. It depends for its accuracy on precision built accelerometers and gyroscopes. An error of one-millionth of an inch in a gyroscope part would cause a drift off course on a moonshot of three one-hundredths of a degree per hour - enough to mean failure.

LEARNING ACTIVITIES

(K-3)

1. Examine a gyroscope at rest, using a small type which can fit in your hand and which is spun by pulling a string. Spin the gyroscope and feel how it resists any effort to change in its position. Feel how the gyroscope gets weaker as it slows down. You can move it more easily with your finger. Paint areas of the spinner part in blue, alternating with yellow.
   a. What do you see when the gyroscope turns at high speed?
   b. What do you see when it slows down?

(4-6),(7-9),(10-12)

1. In the guidance of a space vehicle, what do these terms mean?
   a. Pitch control
   b. Yaw control
   c. Roll control
2. Without drawing a space vehicle, and using a thick brush dipped in ink, represent pitch motion by vigorous brush storkes. Do the same for yaw, and roll. Study the brush paintings of other students. Discuss:
   a. Which paintings express the terms most successfully?
   b. Why?
3. Re-draw a clear pitch motion using the black brush stroke. Superimpose onto your painting, using red color, a representation of the jet thrust which the astronaut would use to create the pitch motion.
4. Combine into one painting representations of two or three motions, such as pitch and yaw, and, with different colors, show the thruster operations which would cause the motions you have painted.

TOPIC 3.08

Space Vehicles: Communications and Telemetry

Telemetry permits us to know on Earth what is happening in a vehicle far in space. It involves the radio transmission of a measurement of some kind, such as acceleration, course, voltage, pressure, or temperature. To accomplish this transmission, new types of transducers, or energy transformers, have been developed so that, for example, a temperature is not measured by a thermometer which has to be looked at, but by a thermoelectric device which produces voltage changes which, in turn, are transmitted for recording or display at a remote location.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. Telemetry permits us to take an observation and convert it into another form so that it can be transmitted across a distance. The receiver converts the information as received into still another form or display so that he can understand the original observation. Construct a Sensing Box in this manner: Cut a hole at one end of a box large enough to take your hand. Place inside this box commonplace objects of varying size and textures. These objects should not be seen by the students. Choose objects which opposite characteristics such as: smooth-rough, hard-soft, thick-thin, straight-curved, pointed-blunt, wide-narrow, wet-dry. (Examples of materials: corrugated cardboard, wicker, metal, fur, wood, plastic, burlap, sandpaper, nails, seeds, cloth, twigs).

a. Allow the students to feel all the objects through the hole.
b. Have each student draw the objects he identifies.
c. When the drawings are complete, open the box and observe the objects within.
d. Compare what you now see with the drawings you made based on what you felt.
e. How reliable is your "telemetry" linking from your finger-feel to your brain, without your eyes to help?

2. Try it again with a different set of objects, and with more complicated objects which include several textures in one (a screwdriver with a wooden handle, and a screwdriver with a plastic handle).
   a. Can you tell the difference?
   b. Do you think that your ability to interpret what you feel improves with practice?

TOPIC 3.09

Space Vehicles: Inside the Manned Spacecraft

In the first NASA manned spacecraft, the Mercury capsule held one man. His life-supporting suit, fitted to each individual astronaut, was plugged into connections in the capsule. He reclined on a couch at the bottom of a cone-shaped space about six feet across and eight feet high. Packed as this space was with equipment, he had about as much room as a large man would have in a small compact automobile. He rode face-up at launch and facing backward during orbit and re-entry. His controls and instruments were close by his sides and in front of him. Lights flashed green for proper functioning of different systems, red for malfunctions. Instruments showed flight information: attitude, pitch, roll and yaw.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Examine photographs of the interior of the Gemini capsule. Look particularly at the instrument panel and the control handles. After studying the photographs, plan a full-sized, simplified mock-up of the control panel of your own spacecraft as you would like it. Use large sheets of cardboard, fastened to the wall, to begin to construct your mock-up. Place a chair so that you can reach your controls and instrument panel while "strapped" in your space seat. Make your controls and instruments of wood, paper, and wire, by twisting, cutting, bending, folding, piercing, and fastening these materials to the background.
   a. What controls and instruments must you have to fly in space?
   b. What else must you have besides controls and instruments? (Communications, life support systems..)
   c. If you were allowed to take one article of your choice other than what was officially required - what would you take?
   e. What things should be nearer him and what things should be nearer you?
   f. Should you both be able to reach everything?

(10-12)

1. Most warning instruments have words written on them to identify the function or equipment status which may be in trouble. Critical situations require prompt identification of the problem so that corrective action can be taken immediately. Design symbols that you think will identify more clearly and quickly than words the following functions or equipment status:
   a. Thruster Fuel Level
   b. Compresser Pump
   c. Oxygen Pressure
   d. Radio Battery Voltage
   e. Hatch Open
   f. Drogue Chute Deployed
   g. Panel Light Battery Voltage

TOPIC 3.10

Space Vehicles: Outside Activity (EVA) and Docking

During the NASA Gemini flights, extra-vehicular activity by the astronauts truly put Man himself into space. He first roamed outside, tethered at the end of a gold-plated lifeline, on Gemini 4, and succeeded in doing hours of manual work during his space walk on Gemini 12. He moved from his own capsule to another target vehicle with which he had rendezvoused and docked. The two docked vehicles moved together under power as one, and the full potential of assembling large spacecrafts from components boosted separately into earth-orbit lay ahead.

LEARNING ACTIVITY

(K-3),(4-6),(7-9)

1. Astronauts working in space must learn new ways of controlling their movements and new methods for holding tools and objects with which, or on which, they are working. The simple act of writing on a piece of paper can be difficult if there is no desk to put the paper on. Hold a piece of paper in one hand.
   a. Draw a box on it, with crayon.
   b. Write your own address on the side of the box.
   c. How can you improve your drawing without any new materials?

2. Lie on your back on the floor and draw with crayon. Complete as many crayon drawings as you can in ten minutes. Compare your first drawing with your last.
   a. Which drawing is clearer?
   b. Which do you like better?
   c. Can you think of ways to avoid tiring your arms?
   d. Can you determine among another student's drawings which were done first and which were done last?
   e. Can you fool another student by drawing in a particular way?

(10-12)

3. Imagine yourself as an astronaut walking in space.
   a. Paint a picture of what you would see as you did work on the outside of the Gemini space capsule.
   b. Show some tasks being done on the night side of Earth and other tasks in the daylight.
   c. Show closeups of your hands performing these tasks as you would see them as you worked.
   d. Show the other parts of your body which you might see.
   e. Show your fellow astronaut through the capsule window.
   f. How much sky or Earth detail should you show in the background?

TOPIC 3.11

Man in Space: His Body

To survive in space, a man needs a continuing supply of water, food, and oxygen; he must remove his wastes; and he must maintain his environmental temperature, air pressure, and gravity. He must also protect himself from the dangers of space travel: radiations that can burn and destroy, meteoroids that can smash and tear, accelerations that can burst and crush. His equipment and his craft are designed, therefore, to bring a small portion of his earth environment with him and to sustain and protect that earth-cell with him in it.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. The astronauts physical activities are limited by the fact that he either must be connected by tubes and cables to a life-support system or must carry it with him as part of his space suit or must be confined within a life-supporting environment cell. The astronaut must function within the limitations imposed upon him by the mission. Permit the students to experience some of the limitations by doing the following exercises:
   a. Have all students stand in the classroom, beside their desks, and, without, leaving that area, jump around and cavort with arms, legs, and head, as wildly as they desire.
   b. Now, have all students line up in the aisles at arm's length apart. Repeat the first exercise but all students must accept the rule that they may not touch any other student in any way!
   c. Have all students hold their right hand over their head and repeat the exercise without moving their right hand or their left leg.
2. Have students suggest other exercises with limitations imposed on their movements.
   a. Would you prefer to accept the discomfort of working in a very hot or a very cold room? Why?
   b. Would you prefer to be assigned to work for 16 straight hours, or for a ten-hour period followed by a four-hour break and then another ten-hour work period? Why?
   c. What kinds of food do you hate?
   d. If you knew you could get no other food for 48 hours would you eat the food you hate?
3. Discuss "Doing your job under difficult conditions".

TOPIC 3.12

Man in Space: His Mind

If his bodily needs are cared for and he is reasonably comfortable, a man's mind can remain alert, unless his spirit or emotions are troubled. Alertness of mind is as vital to any astronaut's performance as his bodily fitness. His physical comfort will be greatly improved in the Apollo capsule, where he need no longer be confined to his spacesuit "earth-cell". The pressurized cabin of Apollo will permit him to move about in the freedom of coveralls. As part of a three-man team, the Apollo astronaut will also get the benefit of greater rest opportunities and specialized duties.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. The ability to observe and remember the details of what has been observed and to de-

scribe these details are all affected by the mental alertness of the astronaut.
2. Make a pencil drawing in as much detail as you can of the front of the house in which you live. Have you shown how many steps there are, how many panes there are in the windows, where the mailbox is, where any trees or bushes are placed?
3. Make a pencil drawing of what you see when you sit on the edge of your bed. Have you shown only what is inside the room or did you remember to show what you may be able to see out through a window or door?
4. Make a pencil drawing of your family car. Did you immediately assume that the drawing should be of the outside of the car? Why?
5. Without using paints, list all the colors to be found on the scenes you have drawn. Label on your drawings where each color is found.
   a. Have you left any areas unlabeled?
   b. Describe what you think you would see if you looked out the window of a capsule in orbit.
   c. Did you describe a daytime scene? Why?
6. Do you think you can develop your power to make detailed observations by practicing?
7. Do you think that comparing the observations of the three men in a team effort like Apollo would help you get a clearer picture of what was observed or just confuse your understanding of the situation?
8. Using photographs of capsule recovery operations at sea, compare the observations of the different members of one group with the consensus of the observations of another group.

TOPIC 3.13

Man in Space: His Emotions

The astronaut is a rare adventurer for our times. He, as the representative of a team of thousands in the NASA organization, physically steps into the dangers and the challenges of space. His fears, like those of all courageous men, are real, but controlled; he acts despite them. His sense of isolation in his precariously maintained little world must be overcome by his training and his confidence in his equipment, his fellow astronauts and himself. And probably soon, his accomplishments and developments will reach the point where, on long flights, his emotional problem will be ... boredom.

LEARNING ACTIVITIES

(K-3)

1. A healthy astronaut experiences many emotions during his mission in space. He must learn to understand and handle his emotions, so that he can carry out his responsibilities. Make a list of emotions that can be recognized by the expression on a man's face:
   a. Fear
   b. Anger
   c. Joy
   d. Excitement
   e. Worry
   f. Surprise
2. Using modeling clay, model a face to portray one of these emotions.
   a. Can you identify the emotion portrayed on other students' face-models?
   b. Can you distinguish among fear, worry, and surprise?

(4-6),(7-9),(10-12)

(The 4-9 group can also profitably carry out the project described above for the K-3 group).

1. Using colored chalks on colored paper make a series of drawings illustrating the emotions listed above.
   a. What colors do you associate with each of these emotions? Why?
   b. Do you think these associations may change as a result of our new space experiences? (Perhaps black, the color of the sky in space, will come to mean exciting adventure rather than dull sobriety.)
   c. What other new color associations can you suggest?
   d. In your series, have you drawn only faces to illustrate these emotions? Why?
   e. How else can you illustrate emotions without drawing faces?
4. Using only black or gray chalk on white paper, make a drawing depicting loneliness.

TOPIC 3.14

Man in Space: His Spirit

No daring adventure can be faced nor challenging problem handled without involving the spirit of man and bringing into the forefront of his awareness a sense of wonder and closeness to God. Whatever his religious conviction may be, man has traditionally connected his thinking about his inner self with his conception of the heavens and the infinite universe.

With all the concentration on the preparation of the physical, mental, and emotional man, the astronaut must also in his own way prepare the inner man for his journey.

LEARNING ACTIVITY

(K-3),(4-6),(7-9),(10-12)

1. After man has established his first colony on the Moon, he may wish to provide for his spiritual needs by erecting a chapel. Working as a group, construct a lunar diorama which shows the lunar landscape and the buildings of the lunar colony but presents the chapel as the focal point. Avoid using conventional building materials such as wood or stone. Do not repeat the traditional architecture of the area in which you live. Construct the chapel so that interior detail can be seen. Plan the interior so that it allows for whatever dress you think the members of the moon colony will be wearing.
   a. Have you considered the character of lunar surface in your chapel design?
   b. Have you considered the problems of the transport vehicles which will be used?
   c. What symbols or tokens of the Earth heritage would you include in the chapel?
2. Draw as many religious symbols of all faith and all times as you can think of. Suggest, for this chapel, a single symbol which could be accepted as spiritually inspirational to all peoples.

TOPIC 3.15

Man in Space: His Perceptions

The impact of his sense-observations on an astronaut during a flight must be carefully disciplined, carefully selected. He must ignore or control his ideas of his physical orientation, and trust his instruments instead. On the other hand, he must be prepared to ignore his instruments when their pattern of information is unbelievable. He must trust his eyes now, and his radar then. He must report a visually observed phenomenon, although it seems fantastic to him. In the final analysis, because of his perception and judgment, Man is the ultimate observatory.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. Like the astronaut, each of us has to learn to be disciplined and to select among our sense observations. Some of these sense observations we have learned to trust, while others we have learned to ignore. Make a list of the daily experiences or sensations that you have learned to trust and depend on. (For example: traffic lights, sirens, clocks, the glow of a hot stove, maps, automatic electric controls.)
   a. Why do you trust these?
   b. Select one example and tell in detail how you respond to it.
   c. Tell under what conditions you would not trust an observation. (For example: a red light at an intersection that remained red for an excessive length of time, or an automobile horn blowing in an empty car.)
   d. What would you use to guide yourself by when you cannot trust what you see?
2. Make a list of visual observations which you know are not what they appear to be. Examples: railroad tracks meeting in the distance, vibrating effects from "Op Art" patterns, vibrating effects from color juxtapositions, desert heat-mirages. How do you know they are not what they appear to be?
3. Create a picture that makes your eye believe something that your mind knows is not so. Use perspective, color, form placement, textural effects, repetition. Examine the pictures of other students. Do the tricks that work on you work on others equally well?
4. Study contemporary and traditional art works for examples of such "trompe l'oeil".

TOPIC 3.16

New Worlds, New "Beings": A "New" Moon

The Moon has been called an archive of space, for its surface remains today as it has always been, uneroded by water and undamaged by atmosphere, glaciers, or man. Studied by man for almost 400 years, our satellite has only just revealed its far side, and has only just permitted close-up photographs by Ranger and Surveyor spacecraft, with resolution of objects less than 12 inches in size. Detailed studies reliably suggest a relatively hard surface to the moon, rather than a thick dust cover.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. Study photographs of the moon taken from the earth, taken from the Ranger and Surveyor spacecraft, and taken from the Orbiter spacecraft. What are the different forces which have created the lunar surface features? Identify specific features giving their specific cause.
2. Make a sandcasting of a portion of the surface of the moon, expressing your own idea of what that portion of the moon would look like. Remember that the final sandcast result is the reverse of your modeled form...hills become valleys...valleys become hills.

(10-12)

1. Develop a sandcasting as described for (K-9) showing the lunar surface. Cast a second piece to express an Earth surface, showing the result of natural forces not found on the moon

Deep Space Tracking Antenna

(water erosion, wind, glaciers). Cast a third piece to express the surface of an imaginary planet which may or may not fit into the conditions known to exist in our solar system. Explain the premises or assumptions that you used as the basis for your planetary surface. Using your own choice of paints (water-base, oil, etc.) paint each of your three castings.

a. What do you choose as moon colors, for a dead, cold, airless surface?
b. What colors are Earth colors: vegetation, seas?
c. Would you consider as Earth colors the colors you might need to show a city? What are your "imaginary planet" colors?
d. Have you used luminescent paints in any of your castings?

TOPIC 3.17

New Worlds, New "Beings": A New Solar System

Mariner II told us that the surface of Venus has a temperature of about 800°F and that it was completely covered by a dense cloud mass at an altitude of about 50 miles. Mariner II had flown by Venus at a distance of about 20,000 miles. NASA's Mariner IV flew by Mars at less than 10,000 miles distance, after a 400-million-mile journey through space. It telemetered back information about the size, gravity, and atmosphere of Mars (Man can probably live on its surface in space suits). Most importantly, it sent back photographs of a surface pitted with craters.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9)

1. These activities are designed to explore the characteristics of vision through various translucent media, as suggested by the view of the surface of Venus through the clouds and mists that cover it. Look through clear glass, stained glass, undulating glass, water-spotted glass, colored fluids, colored cellophane, colored tissue, gauze, etc. Discuss:
   a. Through which can you detect forms?
   b. Through which can you see only light?
   c. Which materials distort lines?
2. Create a picture, collage, or transparency to suggest what you imagine the surface of Venus to be like as seen through a cloud cover. Imagine that there is a lighted "city" of some kind below the clouds; paint how it might look to a close fly-by spacecraft.

(10-12)

1. Proceed as for K-9, then continue. We have some special devices to help us in fog--horns, lights, reflectors -- but how would we change our world if we were always in fog? Discuss:
   a. What colors would guide us most clearly?
   b. What colors would make us feel less closed in?
   c. Do you think you could always live in fog?
   d. Discuss luminosity, luster, irridescence, fluorescence.
   e. How are they different from one another?
   f. How could these and other visual effects be used in a fogfilled world?
2. Experiment with paints and color to produce these effects. Your first pictures in this activity represented Venus as seen through a cloud cover. Using all the effects you have studied, paint a picture as if you were living in the midst of the Venusian mist.

TOPIC 3.18

New Worlds, New "Beings": Interplanetary Space

The collection of data on the mysterious particles of matter in space called meteoroids is the job of Pegasus, a series of giant spacecraft launched by Saturn I. Pegasus satellites travel in easily visible earth orbits, twinkling instead of reflecting a steady light as they tumble in space. The 14-foot wide "wings" of Pegasus are almost 100 feet long, an excellent target for meteoroid punctures. Thus, with instrumentation on these extended panels to count and orient each meteoroid hit, we learn more about the nature of space.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. Pegasus, like any other satellite in orbit, travels around the earth at thousands of miles per hour. Yet when we look at a picture of Pegasus its odd shape makes it difficult for us to think of it as a craft or vehicle capable of moving at great speeds. Sketch a boat at rest which looks as if it would be a slow-moving boat (barge, houseboat, paddle wheeler). Sketch a boat at rest which looks as if it might be a fast-moving boat (speedboat, hydrofoil, destroyer). Re-draw each boat moving at its highest speed. Discuss:
   a. What elements of the sketches of the boats at rest suggest their speed capability?
   b. What elements of your sketches of the boats in motion suggest the motion, the high speed motion? What is the result when you represent a slow-speed boat in high-speed motion? (It becomes humorous.)
2. Give some other examples of humor from contradictory or illogical motion. (Examples: Keystone cops, reverse film sequences, slow-motion races.)
   a. Why are such representations "funny"? (They are unexpected, contradictory.)
   b. Do you think any of our space vehicles look "funny"?
   c. Do they look "fast"?
3. Taking Pegasus as your subject, how would you show in a drawing that it is moving at a speed of thousands of miles per hour? Remember that since it is not traveling through a fluid such as air or water there is no wake, there is no fluid flow around it. There is also no engine exhaust.

TOPIC 3.19

New Worlds, New "Beings": A New Look at the Stars

Special instruments carried into space on NASA rockets have confirmed one of the most exciting discoveries of space astronomy - "X-ray stars". These startling outer space sources do not reveal themselves by visible light or by radio emissions. Other NASA projects, using ultra-violet telescopes and high resolution film and TV cameras, are studying other types of energy emission from stars, double stars, and nebulae in interstellar space. Even our own star, the sun, has been studied and recently photographed in eclipse by an astronaut's hand-held camera.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. This is intended as a deliberate, but not too disrespectful, fun-project. Imagine that you have travelled into a solar system which has at its center not a sun or star like ours, but rather an "X-ray" star. You have landed on the planet C-All...and you find that everything appears as it would on an X-ray plate in your doctor's office.
2. Using black and white tempera, plus one other color (red or violet) create a painting based on your reactions to the following themes:
   a. Your expedition is prepared to establish a colony on a new planet.
   b. Different groups are organized to build your camp, to establish contact with Earth, to explore the new planet, and to prepare the space vehicle for its return to Earth.
   c. New "Beings" are discovered who have an unusual characteristic; when ordinary light is shone upon them you can see their bones but under X-rays they look perfectly normal. By their actions it soon becomes clear that the New "Beings" are also capable of reading the Earthmen's thoughts....
3. With this thematic tone of space-fantasy, and the humorous aspects of the X-ray environment (and ignoring its dangers) the students should develop a response freely, using the limited palette as suggested. The student should experiment with hard and soft lines, blurred effects, luminous effects, and mood-forms to maintain the character of the eerie situation.

TOPIC 3.20

New Worlds, New "Beings": New "Beings"?

Does life exist elsewhere in the universe? What is it like, if it does exist? Is it possible that we may even pass it by because we don't recognize it? Mars offers the greatest possibility of life in our solar system as verified by Mariner, although Venus is still also a possibility. Anxious as we are to encounter new beings, we are also fearful of the harm we may bring to them through exposing them to earthly organisms which may destroy them. NASA experiments in Exobiology - the study of life that may exist beyond the earth - will begin with automatic sample collection and analysis by soft-landed payloads.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. As a group, have the class engage in various activities which distort or modify human appearance. (Examples: looking into distorting mirrors, pushing and twisting their own facial features, looking at each other through magnifying glasses, putting on stocking masks, putting on grotesque Halloween masks, putting on

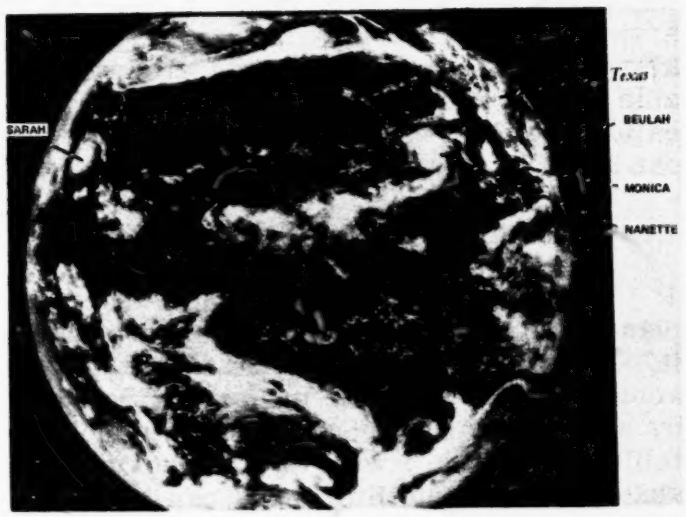
clothing backwards, too-small clothing, too-large clothing, and arranging hair or makeup on unusual ways.) A group discussion should follow which explores:

a. What changes in human appearance do we consider funny?
b. What changes in human appearance do we consider sad?
c. What changes do we consider frightening? Is it not true that an added feature becomes funny, while a lost or damaged feature becomes sad?
d. At the circus, what is the difference between a clown and a freak?
e. How does our environment determine what we look like, and therefore, what looks we like?
f. How does function determine appearance? (Examples, anteaters, kangaroos, giraffes, deep sea fish).

2. Imagine the conditions of a particular planetary environment (considering gravity, atmosphere, water, temperature, etc.). Using wire, wood, plaster, cloth, metal, junk, glass, vegetation, yarn, plastic, foam, hair, fur, stuffing materials, etc., assemble a New "Being" in three-dimension.

a. State whether you think your New "Being" is funny, sad, frightening, or neutral.
b. How would you change it to give it another character?
c. Do you think you could train yourself to live with your New "Being" without thinking that it is funny, sad, or frightening?
d. How would you expect "him" to react to you?
e. Do your classmates have the same reaction to your "Being" as you do? (Group Discussion)

Satellite Photos of Storms



TOPIC 3.21

Our New Earth: Satellite Meteorology

Tiros started, and Nimbus continued, the application of Earth-orbiting satellites to the study of weather. When it was first realized many years ago that accurate forecasting of local weather would require coordinated global study of meteorological conditions, a vast network of observation stations was set up to exchange world-wide data. Now, NASA developed satellites provide a continuous surveillance, tracking hurricanes, offering day or night photographs of cloud cover with excellent resolution, and delivering a reliable 24-hour-a-day weather watch.

LEARNING ACTIVITIES

(K-3)

1. Have the class study photographs or slides of the various clouds and cloud formations. Identify the clouds by name and discuss the types of weather generally associated with each type of cloud. Have each student select his favorite type of cloud and draw a seashore scene with chalk on colored paper which involves the cloud he has chosen.

(4-6),(7-9),(10-12)

1. This activity should be carried out using the medium of crayon batik (this technique involves drawing first with wax crayon on paper and then painting over the entire surface with dark tempera or water color). Using newspaper clippings or magazine articles of disastrous hurricanes or storms at sea, discuss the threat of violent weather to Man and his civilization. Also discuss:

a. How man prepares to protect himself and his property when he has sufficient warning.
b. Warning systems, old and new.

2. Choose one of the following settings for your storm picture:

a. City street,
b. Farmhouse,
c. Ship on the ocean.

Render this picture in crayon batik stressing the power and destructiveness of the storm. Now re-draw this scene as it would be seen from a Nimbus satellite. Discuss:

d. Have you been able to retain any details at all?
e. Or has the picture become impersonal?
f. Which of the two pictures of more effective in expressing the storm?

TOPIC 3.22

Our New Earth: Just Another Planet

As we would study Mars or Venus we now look anew at our own planet, Earth. NASA's geodetic Explorer satellites are revealing new information about the Earth's size, shape, and mass, the variations in its gravity, and the distances between points on its surface. We have learned that not only is the Earth pear-shaped, but its waistline, the equator, is elliptical rather than circular. Close coordination of satellites with both fixed and transportable ground stations have made possible this accurate geodetic study of Earth.

LEARNING ACTIVITY

(K-3),(4-6),(7-9),(10-12)

1. Student activities using a potter's wheel to create ceramic pots, bowls, and vases can be planned around a discussion of the forces which determine the shape of a planet. Such "generated" forms are the result of the rotation of matter under the influence of a variety of forces. Almost any finger pressure or blow or tool applied to the turning clay can be an expression of such forces. We once thought of the Earth as a perfect globe, then as a sphere pushed in at the top and bottom, and now we think of it as pear-shaped. With not a very great stretch of the imagination, planetary forms of all shapes can be conceived. (Dumbbell, rolling pin, bell-shape, etc.) It is conceivable that even spiral forms may exist in space.
2. Starting from a spherical ball of clay, have each student throw a "planet" on the potter's wheel. The "planet" should be planned so that it results in a functional object (bowl or jar), so that the student is actually making the functional object but using the planetary suggestion as the basis of his design. The surface of his object should be sculpted to further suggest his ideas of the surface of his "planet". In the final stage of producing his object, a glaze should be applied, again consistent with the student's concept of this imaginary planet.

TOPIC 3.23

Our New Earth, New Communications

Syncom III, the first stationary satellite, flies in orbit at 22,237 miles above the Earth. As with any synchronous satellite, its speed is just right to coincide with the speed of rotation of the Earth below it. Therefore it remains, to a viewer at a ground station on the surface, always overhead, always in sight, always available for relaying direct TV or other communications between any two points on Earth that can see it.

LEARNING ACTIVITIES

(K-3)

1. To a viewer looking from a distance at a planet with synchronous satellites in orbit about it, the satellites will appear as if they are actually attached to the surface of the planet by a great invisible supporting rod. Since satellites can and do have a large variety of "odd" shapes, these satellite forms can be represented by almost any found object. Have the student gather a group of "satellites" from found objects (lollypops, hatpins, keys) and "put these in synchronous orbit about a planet" by attaching them to a "planetary shape" derived as discussed in the previous activity. If the planetary form has been mounted so that it can be rotated after the "synchronous satellites" have been attached, a delightful rotating Christmas tree effect can be achieved.

(4-6),(7-9),(10-12)

1. The concept of creating a sculptural form by the use of a "generated planetary shape" into which "synchronous satellite shapes" have been attached should be explored and developed into as many variations as possible. At first, emphasis should be on form and form relationships, without regard to color, and with no attempt to introduce motion. Later, these additional elements can be used to increase the visual interest of the sculptures and to express the student's response to the total idea of a planet whose sky is crowded with a great variety of apparently fixed objects.

TOPIC 3.24

Our New Earth: Supersonic Transports

NASA's work in developing designs for supersonic transport (SST) airplanes is not as well known as its space activities. But, for our new Earth, the building of a passenger-carrying airplane that is not only capable of supersonic flight at MACH 3 (three times the speed of sound, or about 2000 MPH at its cruising altitude of 70,000) but is also safe, durable, and economical to operate may have a greater immediate effect that space activities. This program will lead to commercial travel between New York and New Delhi in a flight of about 6 hours in the mid-1970's.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

1. Examine photographs and models of the exterior and interior of the proposed SST airplane designs. Discuss the passenger-carrying capacity and the operation of the airplane (its speed, the duration of flight, handling the baggage, loading and unloading passengers).
2. With this information, design and build, to a selected scale, a mockup of the interior of airplane. The class should be divided into three groups, each of which will concentrate on a specific section of the mock-up; the crew and food preparation compartments, the passenger-seating compartments, and the public lounges and observation compartments. Strong direction should be given to the students to avoid repeating the decor ideas and arrangments of our existing jet transport airplanes. Designs which minimize the sense of coldness, crowd-

edness, impersonality and the mechanistic character of high-speed mass transportation are to be sought, while maintaining reasonable efficiency of operation.
3. Then, have each student individually design the external decoration of the airplane, particularly including a new symbol for the SST airplane of a selected airline. Again, direction should stress the creation in the symbol of a sense of human involvement and warmth, while retaining the suggestions of great speed and security.

TOPIC 3.25

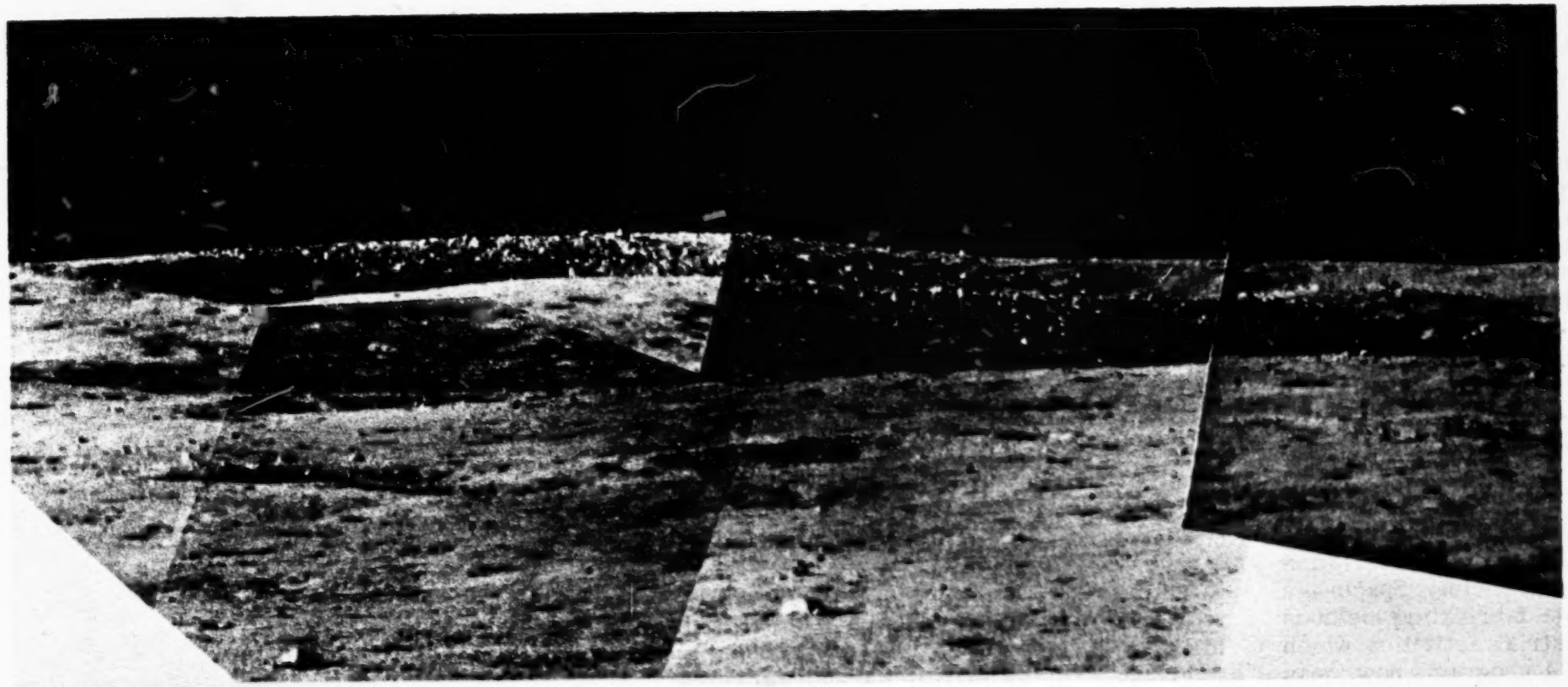
Our New Earth: A New Society

Supersonic transports, satellite communications, and greater certainty in weather forecasting are but a few of the characteristics of our new space-oriented society. Space-age materials and space-age fabricating methods derived from the industrial activities which have supported the NASA programs now mean more durable, adaptable, and inexpensive things for the home and the community. Above all, the new space orientation requires continuing planning and cooperation for the application and expansion of our new knowledge of the universe.

LEARNING ACTIVITIES

(K-3),(4-6),(7-9),(10-12)

The following student activity is intended for all grades but the media used should be: K-3, torn paper; 4-9, tempera; 10-12, mosaics.
1. It is inevitable that a space-oriented society will be distinctly different from our present one. Changes in transportation, communications, weather control, and materials for daily use will bring the wonders once projected for the twenty-fifth century into our lifetime. A mural is an heroic art form which attempts to portray the artist's feelings about his time, his place, or some other subject of great scope. A group-executed mural, therefore, presents an excellent opportunity for a final student activity inspired by what we have called "the NASA adventure". The mural, to be executed in varying degrees of technical complexity as suggested by the media selections listed above, should reflect varying degrees of awareness of the impact of this adventure on our existing society. The technological impact is more direct and obvious. The political and economic impacts require perhaps more sophistication to appreciate, and therefore, it would be expected that evidences of such impacts would appear in the murals of the two older age groups.
2. The phychological and psychic impact, it may be hoped, will be expressed in the oldest group's work. The artistic theme in all groups should not be "Space Comes to Man", but rather "Man Comes to Space".



Five-frame mosaic of the lunar terrain near Surveyor VI shows a strewn field of rocks, the source of which is not seen. The rocks, some as large as 1.5-2 feet across, probably were thrown out of a crater beyond the horizon and to the left. They are scattered over the two subdued craters seen below the horizon. The horizon is formed by a low ridge which trends northeast across the surface of the Moon's central bay (Sinus Medii) and is one of a family of typical lunar mare ridges. Each of the pictures, taken during a narrow-angle sequence on November 10, 1967, covers a field of view of six degrees.

4. Science: Elementary

by Dorothy J. Kunde

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Science: Elementary

by Dorothy J. Kunde

INTRODUCTION

"It has been said that the real and legitimate goal of science is the endowment of human life with new inventions and riches. That is the real goal of our own space effort in America. You are helping to endow all of human life, in all lands, with new inventions and with new riches."

President Lyndon B. Johnson
September 27, 1966
Cape Kennedy, Florida

Probably no other area in the field of elementary science has attracted so much attention and has grown so rapidly as that of aerospace.

Because it involves the various disciplines of science so extensively and in such variety, and perhaps because the children seem to "know" so much because of the mass media coverage of the dramatic events involved in the man-in-space program, the elementary teacher sometimes finds it difficult to cope with the ever increasing wealth of information which should be presented in the elementary grades.

In this resource guide, no attempt has been made to outline a complete aerospace curriculum but only to sight major concepts and generalizations. Activities are provided which will assist the teacher in guiding pupil experiences effectively.

It should be noted that wherever possible the concepts and related activities presented are designed for direct pupil participation. Some of the suggestions will include experiments and demonstrations already used in the classroom but the applications may vary according to the new concepts and their development.

As in all areas of the curriculum, the classroom teacher should be the final judge of appropriate material but it is hoped that the activities found in this guide will serve to enrich and to further motivate the investigations of the space age.

TOPIC 4.01 (K-3)

A satellite is a smaller object that revolves around a larger object. The moon is a natural satellite of the earth. Man has made artificial satellites.

LEARNING ACTIVITIES

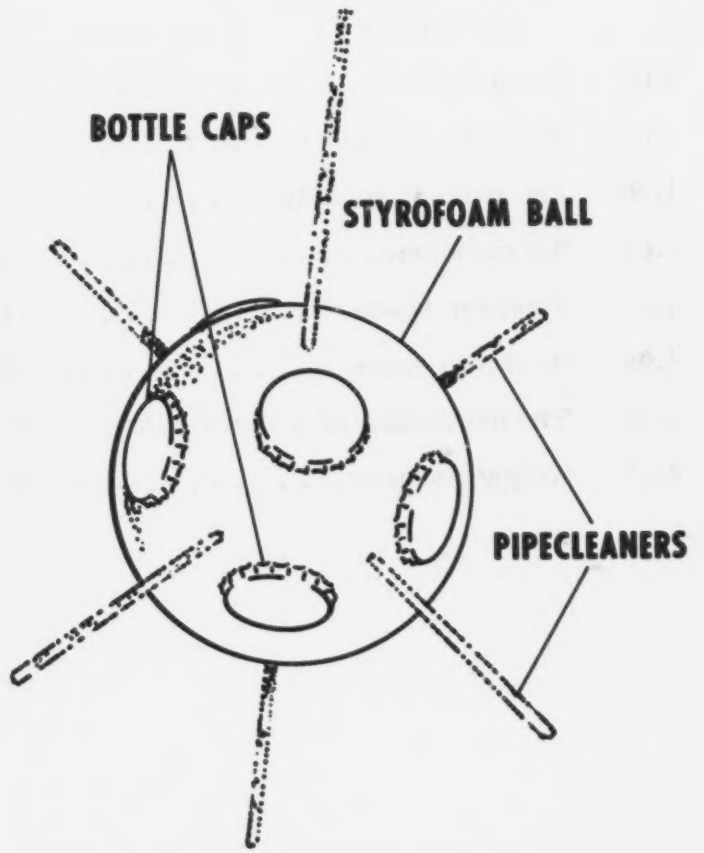
1. When the moon is in the daytime sky, take the children outside to observe its position on successive days. (It is only visible in the daytime sky when it is on the same side of the earth as the sun.)
2. Have the children follow the movements of the moon across the sky during the period of study. Check to see if the moon is always in the same place in the sky.

REINFORCEMENT

1. Have the pupils make a large mural of the solar system. Have them cut models of the planets and sun out of construction paper and place them on the mural. Show their orbits. (Children should be reminded that the various sizes are not accurate.)
2. Through the use of a planetarium help the children observe the orbits of the earth around the sun and the moon around the earth.
3. Vanguard is a satellite which can easily be "pupil-made".

MATERIALS: Styrofoam ball (6" diameter), pipe cleaners, aluminum paint, bottle caps.

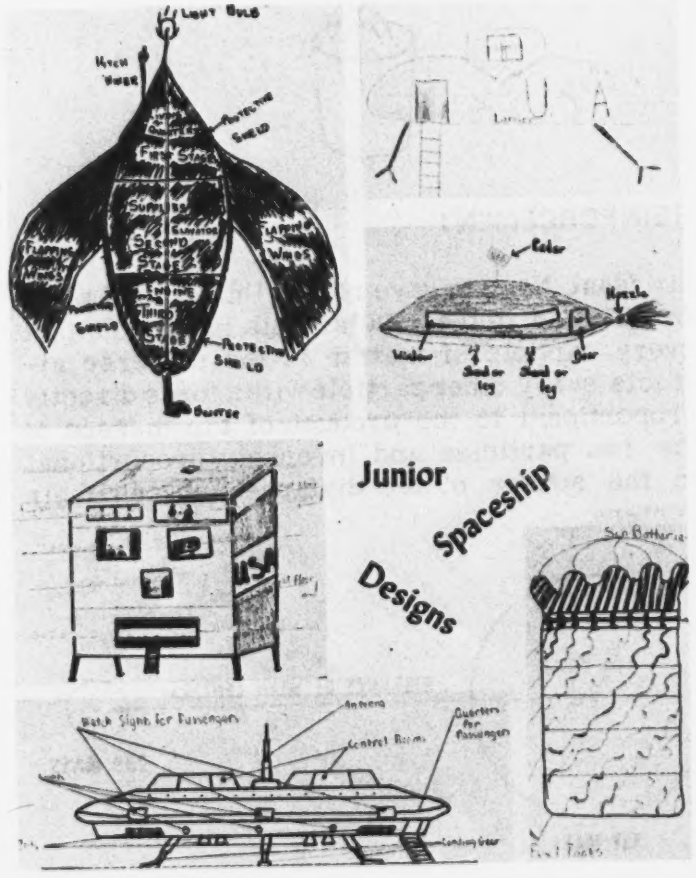
PROCEDURE: Paint styrofoam ball blue. Paint the pipe cleaners aluminum. Insert pipe cleaners along 3 axis.

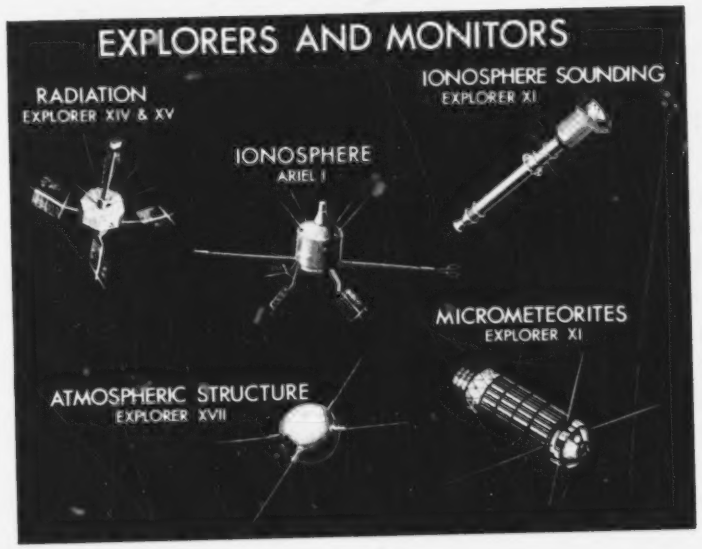


REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Short Glossary of Space Terms, 2nd edition; NASA SP-1; Supt. of Doc.; Price: $.25.





TOPIC 4.02

(K-3)

The Earth is a great ball turning in space. We are using satellites to study the size and shape of the earth. The science of studying the size and shape of the earth is called geodesy. Satellites which study the size and shape of the earth are called geodetic satellites.

LEARNING ACTIVITIES

1. To develop the understanding of the shape of the earth, have a pupil hold a little ball close. Observe the roundness. Now have him stand close to a big ball. Observe the fact that it does not seem as round. Compare what has been observed with the large size of the earth and point out that we are close to the earth and it is so large that we do not see its roundness.
2. In relation to the above demonstration, discuss the findings of our astronauts and display pictures taken in space. Students will want to bring in pictures to show their classmates. Students will realize that if the astronauts were farther from the earth, the earth would look more like a globe. Ask them what shape the earth would have if they were looking at it from the surface of the moon.
3. We have observed the earth's shadow on the moon during an eclipse of the moon and have noted the round shape. The students can make drawings which will demonstrate solar and lunar eclipses.

Australia from 6500 Miles High

REINFORCEMENT

The students should now be ready to think about small, unmanned satellites in orbit around the earth. These satellites, with special instruments, can study the size and shape of the earth-geodesy.

Vanguard I was launched in 1958. It weighed only 3 1/4 pounds and was about the shape of a grapefruit. It told us that the earth is slightly pear-shaped.

Sir Isaac Newton showed, nearly 300 years ago, that the earth was not a sphere.

The deviation from the spherical shape, only a few feet, is so small that it cannot be observed visually.

Other geodetic satellites are the PAGEOS and GEOS. PAGEOS means "Passive Geodetic Satellite" and GEOS means "Active Geodetic Satellite".

By precise tracking of satellites, and analysis of the changes in their orbits due to the irregularities in the mass of the earth, we can determine the location of land masses.

ACTIVITIES

1. Illustration of the causes of day and night.

Materials: Globe, lamp, plastic ball with string attached.

Procedure: In a dark room, shine the light on the globe. Rotate the globe. Carefully observe as the globe rotates. (Be sure to have pupils rotate the globe counter-clockwise.)
Now hold the string attached to the ball and have the ball revolve around the earth. Could this represent a satellite such as Vanguard, PAGEOS, or GEOS? Would it also experience day and night?

2. Relate the ball in orbit about the earth to the moon in orbit about the earth.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Short Glossary of Space Terms; 2nd Edition; NASA, SP-1; Supt. of Doc.; Price: $.25.

Dictionary of Technical Terms for Aerospace; 1st Edition; NASA, SP-7; Supt. of Doc.; Price: $3.00.

EP-25 Space Exploration - Why and How

TOPIC 4.03

(K-3)

Due to the organization of the solar system, the motion of the bodies within it are predictable. The organization of the Solar System seems to be largely due to mutual gravitation and inertia. Due to information from man-made satellites, we are able to refine our data on the motions of the natural bodies in space and make more accurate measurements.

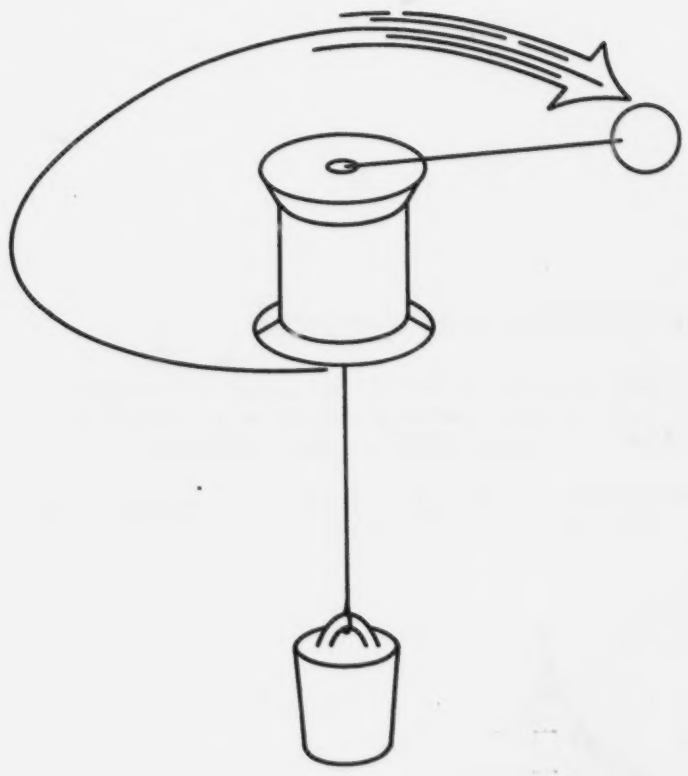
LEARNING ACTIVITIES

1. The students can investigate this predictability in many ways. They can compare the sunrise and sunset times listed in the local newspaper with actual observations. Many newspapers list the time and location of visible satellites, such as Echo and Pegasus. Planetariums also publish satellite visibility charts. Star charts will tell them when and where constellations are visible.

2. The force of gravity and inertia must be balanced in order for a satellite to remain in orbit.

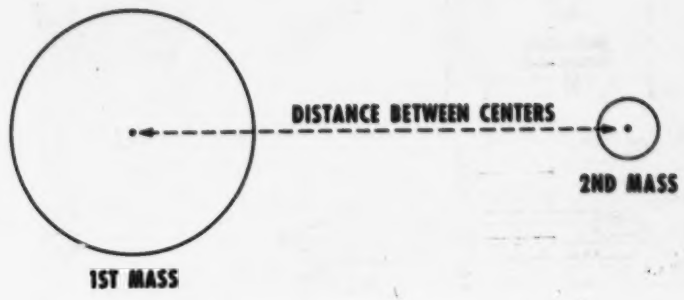
Materials: Three feet of heavy cord, rubber baseball, eye hook, one pound weight, and wooden spool.

Procedure: Attach eye hook to the ball. Run weighted cord through the spool and attach to the eye hook. Swing the ball around until the inertia of the ball counterbalances the weight. Observe what happens at varying velocities. Discuss what forces affect a satellite and what keeps it in orbit. What would happen if we cut the string? Would this represent escape velocity? What does varying the velocities show? How could we show an elliptical orbit using this device?



REINFORCEMENT

Sir Isaac Newton gave us the Universal Law of Gravitation in the 1600's. This law states that every particle of matter in the universe attracts every other particle with a force directly proportional to the product of the masses of the two particles and inversely proportional to the square of the distance between their centers.



As the distance between centers increases, the force of gravity decreases rapidly.

Force of gravity does extend to great distances and never ceases to exist entirely. The Sun is 93 million miles from the Earth, but the gravitational force between them holds the Earth in solar orbit.

Newton also gave us the law of motion which states that a body either remains at rest or moves with constant speed in a straight line until it is acted upon by an external force.

1. Investigate the types of orbits satellites can follow around the Earth. Syncom has an orbit quite different from Nimbus.
2. Discuss the fact that a satellite is influenced not only by the Earth's gravity but also by the gravity of the Sun and Moon.
3. Investigate the influence other planets have on spacecraft traveling beyond the Moon.
4. A study of the trajectories of the fly-by missions of Mariner II to Venus and Mariner IV to Mars will help the students understand why it is important to have accurate information on the motions of bodies in space.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NF-26 Mariner IV, Vol. II, No. 9, 1965.

TOPIC 4.04

(K-3)

Because of the weight of the atmosphere, there is air pressure. The air pressure becomes less as we increase our distance from the surface of the earth. We can use sounding rockets to study the atmosphere at high altitudes.

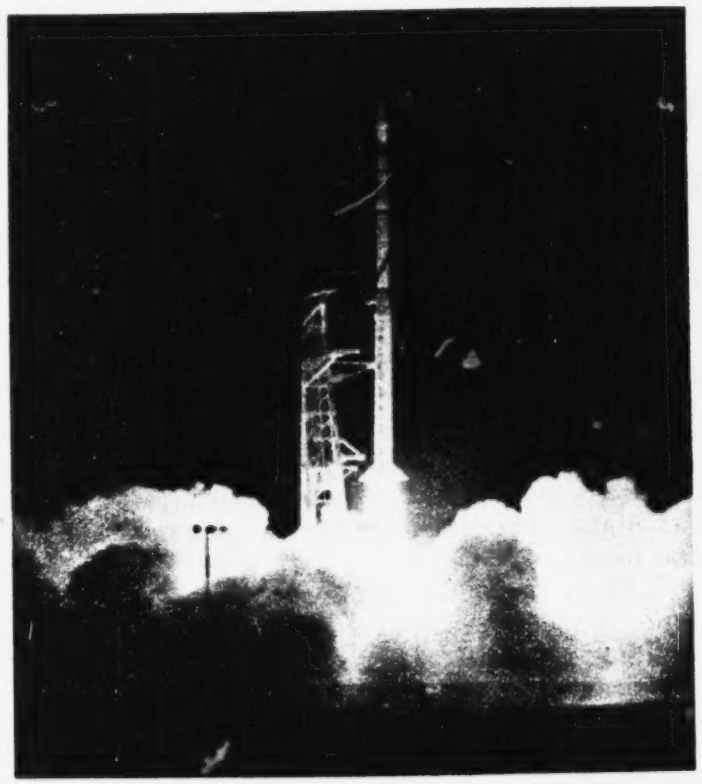
LEARNING ACTIVITIES

1. Discuss various everyday observations which illustrate air pressure; conventional commercial aircraft which must be pressurized; X-15 experimental tests require the astronaut to wear a pressure suit; Apollo astronauts have special space suits to wear when the command module has been depressurized, etc.
2. Have students define space. You will find several different definitions because of different viewpoints. The aeronautical engineers, radio and radar technicians, test pilots, aerospace physicians, astronauts, etc., define space as it applies to their specific fields.
3. Air pressure makes it possible for us to drink through a straw.

Materials: Milk bottle, rubber stopper, straw.

Procedure: Make a hole in the stopper of a milk bottle, just large enough for a straw. The place where the straw passes through the stopper can be made air-tight by applying melted candle wax or sealing wax. Have a pupil suck the milk through the straw. If the bottle is really air-tight, this will be impossible to do. Make another hole in the stopper and ask the pupil to perform the same experiment. The milk should be easily sucked from the bottle. When an astronaut is drinking a liquid in a depressurized spacecraft, he has two major problems: (1) No air pressure which would allow him to use a straw, and (2) apparent weightlessness which causes liquids to form small spherical globules and float in the container. Therefore, the liquid must be in a container which will permit the astronaut to squeeze the liquid out and into his mouth.

4. Many students have ridden in an automobile over mountains and experienced a strange feeling in their ears. Discuss this change in air pressure and what the hazards would be for the astronauts' ears if they did not have space suits or a pressurized cabin.



SCOUT

Scout, the smallest of the basic launch vehicles, was designed to provide a reliable and relatively inexpensive launch vehicle for smaller payloads and small satellite missions, high-altitude probes, and re-entry experiments.

It has four stages, is 72 feet high (less the spacecraft), and has a maximum diameter of 3.3 feet at its widest cross section.

Guidance is provided by a strapped-down gyro system, and the vehicle is controlled by a combination of aerodynamic surfaces, jet vanes, and hydrogen peroxide jets.

The only U.S. launch vehicle with solid propellants exclusively, it has a total thrust of 176,000 pounds and can put a 400-pound payload into the lower levels of space, or can put 240 pounds into a 300-nautical mile orbit, or can carry a 100-pound scientific probe about 7,000 miles away from the earth.

REINFORCEMENT

For many years, the conventional method to use in studying the atmosphere at high altitudes was to use balloons. Today, we use sounding rockets to supplement and increase data on the atmosphere above twenty (20) miles. Rocket grenades are used to obtain data about high altitude winds. The explosions are studied by optical instruments and radar.

Another way for sounding rockets to aid our study of winds is to have sodium released at high altitudes. The sodium vaporizes at the high altitude and causes a glow which is visible at night. This permits optical observations to be made.

Many payloads carried in sounding rockets are recovered. Most sounding rockets do not go more than two hundred (200) miles vertically from the earth. In order to recover the payload, parachutes are used to lower the instruments to the earth or to allow special aircraft to snare the parachute in mid-air.

1. You may wish to have the students discuss parachutes and make some out of squares of cloth. They may even suggest to you that instruments such as thermometers, cameras, collection devices, etc., could be sent to high altitudes and recovered safely.
2. The students may watch for news accounts of the launching of sounding rockets with names like Aerobee, Deacon, Viking, and Scout.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-27	Meteorological Satellites and Sounding Rockets
EP-45	Fifty Years of Aeronautical Research
NF-8	Launch Vehicles
NF-9	Manned Space Flight: Projects Mercury and Gemini
NF-23	Manned Space Flight: Apollo
NF-27	Living in Space

TOPIC 4.05

(K-3)

Gravity pulls everything toward the center of the earth. "Up" is away from the center of the earth. "Down" is toward the center of the earth.

LEARNING ACTIVITIES

(Keep in mind that scientists haven't explained gravity satisfactorily as yet.)

1. Have pupils make figures to represent the children of the different continents. Place these figures on the globe on the various continents. The figures can be attached with modeling clay. Note that the figures all point to the center. Let them see the directions in which balls would go "up" if they were thrown by the children on the different continent. The ball going "up" in North America would travel in the same direction as the ball coming "down" in Australia.
2. Experiment with and discuss the everyday experiences which illustrate gravity-toys falling to the floor, water pouring out of a cup falls "down" not "up", an object falls to the bottom of a pan of water.
3. Discuss life without gravity.
4. Have one child hold a volley ball or basketball over his head for several minutes. Have him describe how it feels. He will no doubt tire quickly, and will indicate that his arms ache. Discuss the amount of human energy needed to hold up this object. Discuss the role of gravitational attraction in "working against" the efforts of man. Relate this need for energy to the energy needed to lift a huge rocket off the ground and out of the earth's gravitational pull.

TOPIC 4.06

Rockets push satellites fast enough and far enough in space so that they are not pulled back immediately to earth by gravity. Hot burning gases within the rocket engine provide the push to send the rocket into space and back.

LEARNING ACTIVITIES

1. On the playground, encourage the children to feel and compare the amount of force or thrust needed to throw balls of different weights to different heights.
2. Problem: How does a rocket work?
   Materials: Balloon
   Procedure: Blow the balloon up and hold it at the neck. Push it at the front. Feel the air pushing back at you. Push the sides. Feel the air push back. Any area which is pushed pushes back. Now release the balloon. It flys away from the hand into the air.

   Explanation: The air was pushing against the inside of the balloon before you let go. Now it rushes out. But the air at the front of the balloon is still pushing forward. So the balloon goes forward. In a real rocketship there is no air rushing out. Instead there are very hot gases. These gases have much more push than the air in the balloon.
3. Tape a balloon to the top of a toy car. Release the air from the balloon and observe the thrust exerted which pushes the toy car.
4. Collect pictures of some of the earth's artificial satellites, such as those in the Tiros and Syncom series. Find out what types of rockets were used to launch these satellites. Stress the fact that rockets are used for many purposes other than launching satellites.
5. Many children at the elementary school level have models of rockets. If a member of the class has such a model, have him bring it to school. Demonstrate and discuss the "stages" of the rocket. (See suggestions, grades 4-6 for additional information on staging in Topic 4.14).

REINFORCEMENT

There are several definitions for gravity varying in the degree of sophistication. One of the simpler definitions states that gravity is a force imparted by the Earth to a mass on or close to the Earth. Mass may be defined as a measure of the amount of matter or number of molecules in a material object or body.

All of our spacecraft are under the influence of gravity. They never escape entirely from a gravitational field. This could be the gravity of the sun, moon, and/or the earth in combination, or the sun and other planets during interplanetary missions.

It will be interesting to point out to your students that once we leave the surface of the Earth and are in space, we generally do not refer to "up" and "down" when objects move.

One area of investigation for our aerospace scientists has been to find out about the effects of the apparent absence of gravity during manned space flights.

When launching a rocket, we must overcome the force of gravity in order to get away from the Earth and into orbit or on a trajectory to a celestial body. This force or push necessary to get away from the Earth is referred to as thrust and is the force exerted by the exhaust of a rocket engine.

As we have learned, it is the difference in pressure inside the rocket that gives us the thrust to make the rocket go. It is NOT the push against the earth or the atmosphere that makes them go. Our rockets work much better in space than they do in our atmosphere.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA, SP-7; Dictionary of Technical Terms for Aerospace Use; 1st Edition; 1965; Supt. of Doc.; Price: $3.00.

NF-8 Launch Vehicles

NF-20 United States Launch Vehicles. (Color supplement to NF-8)

TOPIC 4.07

(K-3)

The spacecraft must be slowed down if it is to return to earth. Retrorockets are used to slow it down. Air is used to slow it down when it enters the earth's atmosphere by use of parachutes.

LEARNING ACTIVITIES

1. PROBLEM: How do retro-rockets work to slow down the spacecraft?

   MATERIALS: Balloon

   PROCEDURE: Inflate the balloon and hold it at the neck. Push in at the front. Feel the air pushing back at you. Push the sides. Feel the air push back. Any area which is pushed pushes back. Now release the balloon. It flys away from the hand into the air.

   EXPLANATION: The air was pushing against the inside of the balloon before you let go. Now it rushes out. But the air at the front of the balloon is still pushing forward. So the balloon goes forward. In a rocket there is no air rushing out. Instead there are very hot gases. It is the difference in pressure (push) inside the rocket that makes it go. On the spacecraft rockets are fired in the direction of flight causing the craft to slow down. Thrusters are fired in order to position the craft so that it will again enter the earth's atmosphere in the proper attitude.

2. PROBLEM: Parachutes and the spacecraft.

   MATERIALS: A handkerchief, some thread, and two corks.

   PROCEDURE: Tie the corners of the handkerchief to one cork. Hold the "parachute" which you have made high. Hold the second cork next to it. Let them both fall. Which falls more slowly? (the "parachute" and cork) The "parachute" had to push air out of the way. This slowed the fall of the chute and its cargo. Ask "how a parachute for heavy things would be different from a parachute for light things?"

   EXPLANATION: The parachute demonstrates that the greater the surface area of the parachute, the more air will collect beneath it causing it to fall more slowly to the Earth. Large weights, such as spacecraft, require very large parachutes and may use more than one.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA, SP-1, Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: S.25.

TOPIC 4.08

(K-3)

Food must be preserved and specially prepared for trips in space.

LEARNING ACTIVITIES

1. Prepare a balanced meal with a blender. Put it into plastic bags. Eat as an astronaut would eat by squeezing the bag.
2. Compare methods of preservation of food in terms of weight, flavor and appearance.

REINFORCEMENT

1. Expose many kinds of food to extremes of heat and cold.
2. Encourage the children to bring in dehydrated foods.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NF-27 Living in Space

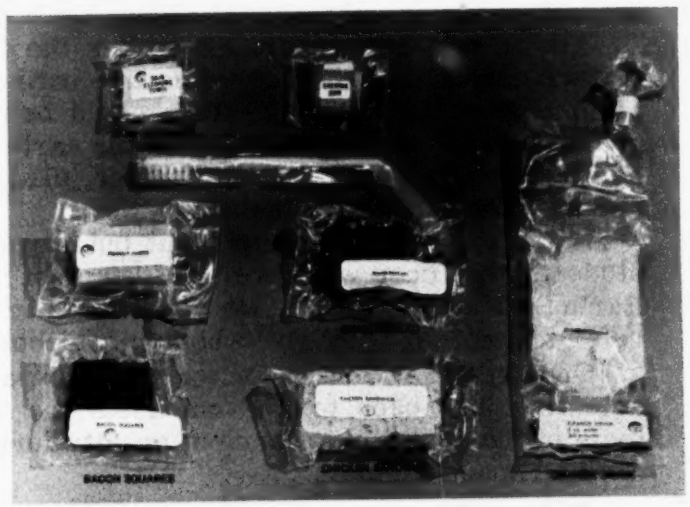
Films:

"Food for Space Travelers," NASA, 1966; sound, B&W; HQK-SR3; 28:31 Min.

"The Four Days of Gemini IV," NASA; HQa-134; Color, Sound, 28 Min.

SAMPLE MENU

	DAYS 1, 5 and 9	DAYS 2, 6 and 10	DAYS 3 and 7	DAYS 4 and 8
Meal No.1	Apricot Nectar Grapenuts Bread Wafers III Mocha Beverage Coffee	Prune Bits Scrambled Eggs Bread Wafers I Milk Coffee	Orange Juice Wheat Chex Bread Wafers III Chocolate Milk Coffee	Peach Bits Scrambled Eggs Bread Wafers III Milk Coffee
Meal No.2	Fruit Cocktail Shrimp Casserole Bread Wafers I Lemon Gelatin Jordan Almonds Coffee	Cream Soup Tomato Aspic Cheese Sandwiches Rice Pudding Honey Squares Coffee	Swiss Steak Mashed Potatoes Corn Apple Pudding Toffee Tea	Tomato Consomme Hamburger Patties Bread Wafers I Coffee Milk Shake
Meal No.3	Beef Salad Bread Wafers II Applesauce Spice Squares Milk Coffee	Blended Juices Beef and Gravy Mashed Potatoes Peas Pecan Bites Tea	Cream of Mushroom Soup Gelatin Fruit Salad Corn Meal Wafers Cheese Cake Bits Milk Coffee	Grape Punch Turkey and Gravy Winter Squash Spinach Bread Wafers III Raspberry Dessert Tea
Meal No.4	Pineapple Juice Breast of Chicken Mashed Potatoes Glazed Carrots Corn Meal Wafers Strawberry Dessert Bites Tea	Vegetable Soup Ham Patties Bread Wafers II Banana Milk Shake Nougats	Grapefruit Juice Chicken a la king Rice Bread Wafers II Pears Coffee Almond Wafers	Blended Juice Ham Casserole Corn Meal Wafers Pineapple Peppermint Wafers Coffee



MENU FOR GEMINI

The Gemini menu ranged from cereals, orange juice and toast to meats, eggs, fish, and fruit salad. For each day, it provided about 2500 calories per person, plus other essentials of nutrition.

Food must be prepared so that it can be consumed by astronauts who are weightless, in an environment where everything is weightless, including the food itself. Solid foods are dehydrated and packed in bite-sized portions, in tubes, or as concentrates enclosed in plastic bags in which water may be added with a water gun. Three meals for each astronaut weigh no more than a pound, on earth.

The astronauts are careful to prevent food particles or water droplets from escaping. In a condition of weightlessness, such particles would drift in the cabin, and could result in problems with sensitive equipment.

TOPIC 4.09

(K-3)

Astronauts must be in perfect health to qualify for space flights. The astronauts experience stress upon acceleration and deceleration of the spacecraft and are protected by the spacecraft cabin and the spacesuits. When returning to earth, the spacecraft passes back through the atmosphere and is protected from the heat of friction by the heat shield. The heat shield on the spacecraft slowly ablates during re-entry, thus protecting the astronauts from the heat of re-entry.

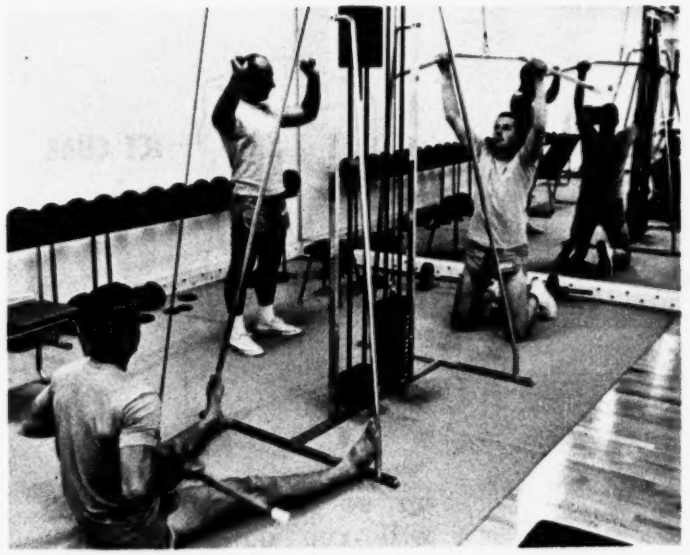
LEARNING ACTIVITIES

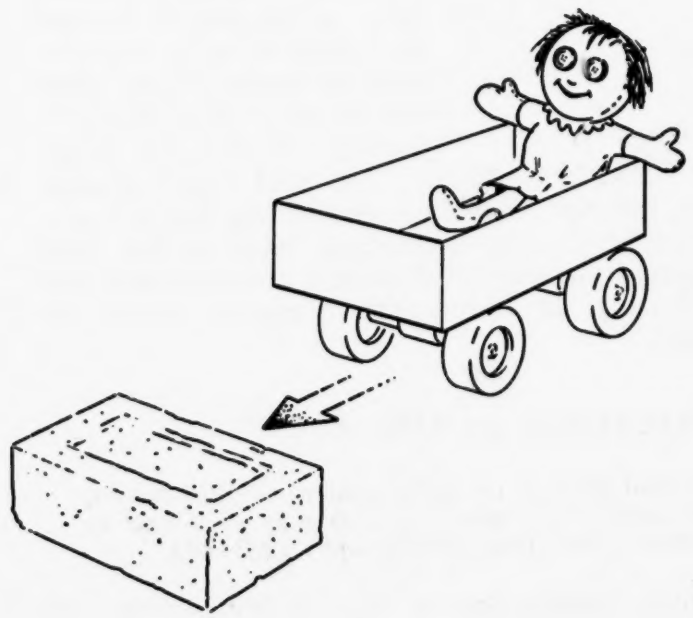
1. Check the health of the class to see if they would be eligible to be astronauts. For example: take the height and weight measurements. Count the pulse before and after exercise.
2. PROBLEM: Deceleration of the spacecraft.
   MATERIALS: One roller skate, brick, string, shoe box, rag doll.

   PROCEDURE: Seat a doll at the back end of a shoe box which has been tied to a roller skate. Give the skate a push so that it will roll across the table and hit the brick. Repeat the experiment with the doll sitting with its back against the front end of the box. Note the difference in what happens to the doll in the second collision compared with the first.

   EXPLANATION: A sudden and drastic change in velocity imposes great stress on a moving object. In the spacecraft, the position and design of the astronaut's couch helps him withstand the forces of deceleration and acceleration.

Astronaut Physical Training





REINFORCEMENT

The physical qualifications for pilot crew members must be met by astronaut applicants. Exceptions to requirements are allowed in outstanding cases. In addition to the physical requirements, applicants must be U.S. citizens or will have become U.S. citizens by an announced date. They must not be taller than six feet and generally not more than 35 years of age.

Scientist astronauts must have a doctoral degree in the natural sciences, medicine, or engineering. Those applicants who meet the preliminary educational and physical requirements are ranked by the selection panel on the basis of scientific qualifications. From this list NASA makes its final selection, following thorough physical examinations of the candidates and a limited program to determine their ability to function under simulated conditions of space flight.

In regard to the selection of astronauts in 1967, the following statement was made by the selection panel:

> "The quality most needed by a scientist serving as an astronaut might be summed up by the single word 'perspicacity'. The task requires an exceptionally astute and imaginative observer, but also one whose observations are accurate and impartial. He must, from among the thousands of items he might ob-

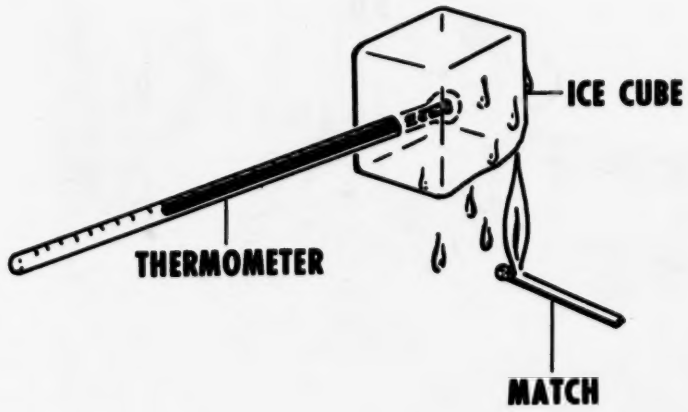
serve, quickly pick out those that are significant, spot the anomalies and investigate them. He must discriminate fine detail and subtle differences in unfamiliar situations, synthesize observations to gain insight into a general pattern, and select and devise key observations to test working hypotheses. He must have the good judgment to know when to stop a particular set of observations and turn to the next.

"The scientist as an astronaut must translate observations into verbal form and be able to generalize from observations to derive appropriate conclusions."

Accepted applicants spend one year in astronaut training; some will also spend one year in flight training to qualify as pilots. Education in specialized fields may also be provided.

Every effort is made to enable the astronaut not only to maintain his scientific competence, but to continue his growth as a productive scientist in his field of interest.

1. Pull a piece of rope through the hand quickly to feel the heat caused by friction.
2. Show the difference between glowing heat (sun) and heat from material being consumed (heat shield), by comparing heat from a light bulb to heat from burning paper.
3. PROBLEM: Illustration of one of the several methods for protecting a spacecraft.
   MATERIALS: One ice cube, small thermometer, book of matches.
   PROCEDURE: Freeze a thermometer into the ice cube. Hold the thermometer in your hand and heat the ice cube with matches. Tip the ice cube



up so the melting water will run down the thermometer stem and not drip into the flame. Observe the temperature change that occurs when the ice cube is heated. Note what happened to the "heated" portion of the ice cube.

EXPLANATION: The heat shield ablates as the spacecraft re-enters the Earth's atmosphere, thus absorbing most of the heat caused by the friction and compression and allowing the spacecraft to remain relatively cool.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA; Project Gemini; Supt. of Doc.; Price: $.45.

TOPIC 4.10

(K-3)

The astronauts must wear special suits which protect them from the hazards of space. The space suits have a layer of material which reflects heat. The space suits are insulated for protection from extremes in temperature.

LEARNING ACTIVITIES

1. PROBLEM: Astronaut clothing
   MATERIALS: One brown paper bag, one metallic ice cream bag, two thermometers, ice cubes, string

   PROCEDURE: Place several ice cubes in both the brown paper bag and the metallic ice cream bag. Place the thermometers in each. Seal the tops. Note the temperature in both bags after several minutes. (The shiny bag remains cooler).

   EXPLANATION: The shiny bag is cooler because the exterior heat is reflected.
2. PROBLEM: Insulation

   MATERIALS: Two jars, heavy wool scarf, hot water

   PROCEDURE: Put hot water into two jars. Wrap one jar in the wool scarf. Wait a while. Find out which jar has warmer water.

   EXPLANATION: The scarf in a very simple way acts as an insulator just as other materials act as insulators in the space suits of the astronauts.

REINFORCEMENT

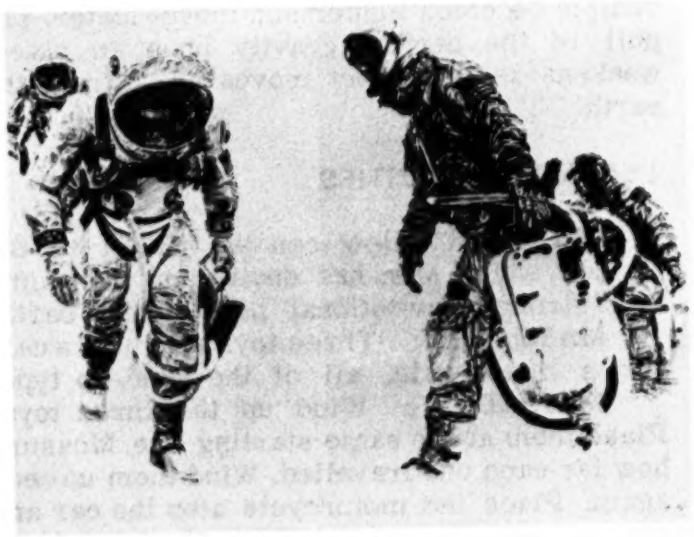
1. Place a sheet of asbestos on a source of heat. Notice that the side next to the heat becomes quite hot, but the side away from the heat does not. (This is another example of insulation so important in the spacesuit.)
2. Discuss the clothes worn during the various seasons and those worn by the astronauts.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Film: "Project Apollo - Manned Flight to the Moon; NASA, HQ 455, 1963; color, sound, 13 min., grades 3 - adult.

Gemini Astronauts



TOPIC 4.11

(K-3)

The astronaut lives in a weightless environment in space. He does not feel the normal pull of gravity

LEARNING ACTIVITIES

1. Discuss the feelings which children might have experienced in riding down in a fast elevator or jumping off a diving board.
2. Discuss life without gravity--man could not walk, lie down, etc.
3. Illustrate the effects of gravity by discussing the fact that all familiar objects (swings, balls, children jumping, ski jumpers, etc.) come down even though they may be propelled a great distance.

REINFORCEMENT

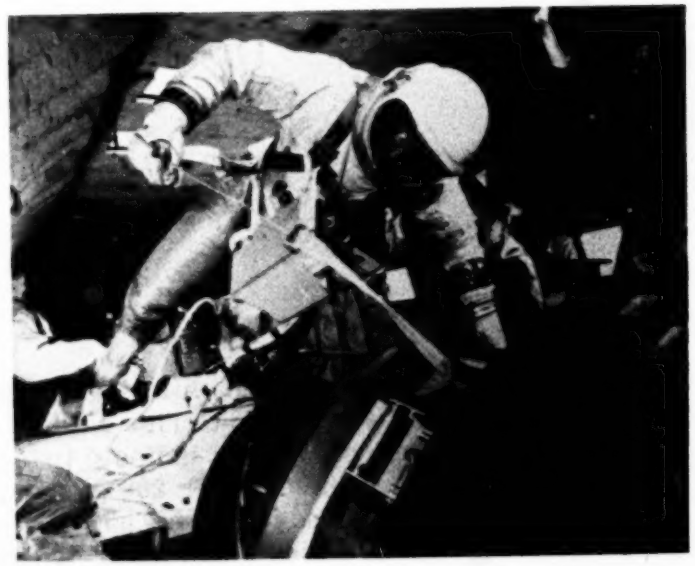
1. Ask one pupil to hold a book in one hand. Notice the weight of the book. Now tell the pupil to drop the hand with the book. The book for a moment seems to weigh much less. Explanation: A falling object seems to weigh very little when the platform on which it rests is falling at the same rate.
2. PROBLEM: Weightlessness in space.
   MATERIALS: Spring scale; a weight.
   PROCEDURE: Hold a spring scale in your hand and hang a weight from it. Note the weight. Now let the scale and weight fall. Catch the scale and weight before they strike the floor. What did the scale indicate while it and the weight were falling?
   EXPLANATION: The satellite and everything in it are falling at the same speed. That is why the astronaut seems to be weightless.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

FILM:
PROJECT APOLLO - MANNED FLIGHT TO THE MOON; 1963; NASA; HQ 455, color, sound, 13 min., grades 3 - adult.

Zero Gravity Simulation



TOPIC 4.12

(4-6)

Weight is a measure of gravitational pull on a mass. We can say that the weight of an object is the G-number for that object to show that it is a measure of the pull of gravitation on the object.

LEARNING ACTIVITIES

1. Form a piece of modeling clay into a ball and weigh it. Now flatten the clay into a thick disk and weigh it again. Thus illustrating that the weight has not changed even though the shape has. The mass may change shape, but the gravitational pull remains the same. This might also be a good time to interject a thought question such as, "Will the clay disk weigh the same on the moon?". (No).
2. Ask a pupil to stand on a scale, record his weight. Now suppose that the scales were

placed on an elevator and the child stands on them while the elevator starts to rise rapidly. For a moment, the scales may indicate twice the normal weight of the child or 200 pounds. A space expert would say that he had "experienced an acceleration of 2 G's or twice the normal pull of gravity". If the elevator should descend rapidly enough, the child's apparent weight might drop to zero. He would then be said to be in a state of "free fall" or "zero gravity". He would be weightless.
3. The above demonstration might well illustrate the fact that a force was needed to raise the elevator and the child against the pull of gravity. The force was registered on the scales.

REINFORCEMENT

Encourage research to determine the relative diameters of the earth and the moon. Have the pupils cut out two circular disks, one 2" in diameter (moon) and the other eight inches in diameter (earth) to show comparative sizes. How does the mass of the earth and the moon compare: (the earth has far greater mass, actually about 80 times that of the moon. The difference in mass results in the moon's lesser gravitational pull.)

TOPIC 4.13

(4-6)

A source of energy is necessary to lift any vehicle off the ground against the pull of gravity. The amount of energy needed depends on the weight of the vehicle and on its destination.

LEARNING ACTIVITIES

Discuss activities in which the pull of gravity must be overcome. (Jumping, walking upstairs, lifting objects.)

REINFORCEMENT

PROBLEM: How can man escape the gravitational pull of the earth?
MATERIALS: Sausage-shaped balloon, piece of string, glass medicine dropper, paper cone for imitation space capsule, two books.
PROCEDURE: Prop the balloon with paper cone attached to one end and the eye dropper tied with a bow knot to the open end of the balloon. (Thus simulating rocket against two books.) Pull the string to loosen the knot. Air rushes out. The blast of air gives the rocket a push or thrust. However, the rocket soon falls back to the floor. Ask why didn't the model rocket continue to fly?
EXPLANATION: The thrust lifted the rocket from the ground. The pull of the Earth's gravitational force brought it back. The force of the thrust was greater than the force of gravitation and acted against it but not for long. There was not enough energy in the air leaving the balloon to keep it going long.

TOPIC 4.14

(4-6)

The earth exercises a gravitational pull so strong that several hundred pounds of propellants are needed to launch only one pound of load. Rockets are usually built in stages in order to overcome this problem. Rockets are often constructed in three sections; the first stage pushes the rocket through the atmosphere; the second stage rocket helps to push the rocket higher, and the third stage rocket pushes the satellite to orbital velocity. The third stage often goes into orbit around the earth. As each stage breaks away, the vehicle becomes lighter and moves faster. The pull of the earth's gravity upon an object weakens as the object moves away from the earth.

LEARNING ACTIVITIES

1. PROBLEM: How can we illustrate the method which Man has devised to overcome this strong gravitational pull of the earth.
MATERIALS: Three toys (a truck, a car, and a motorcycle, all of the wind-up type)
PROCEDURE: Wind up the three toys. Place them at the same starting line. Measure how far each one travelled. Wind them up once again. Place the motorcycle atop the car and the car atop the truck. Allow the truck to go as far as it will, then release the car; when the car stops, release the motorcycle. Observe the total distance travelled by all three toys. How does this distance compare with that travelled by each one?
EXPLANATION: Rockets are usually built in stages as an efficient means for overcoming the pull of gravity. As the propellant in each stage is consumed, the empty section is detached and falls away. Note: it might be well to point out here that a smaller second stage can increase the speed of the vehicle to which it is attached. The second stage fires when the rocket is beyond the dense atmosphere near the earth.

2. PROBLEM: How could you get across a desert to the nearest oasis 600 miles away? Use the materials suggested below.

MATERIALS: One truck, one jeep, and one motorcycle, each with a range of 200 miles. The gas tanks are full and sealed.

EXPLANATION: Clearly the use of the various vehicles carrying them as the rocket does its stages will solve the problem.

REINFORCEMENT

1. TOPIC: Further illustration of staging

MATERIALS: Several baseballs, a pair of roller skates

PROCEDURE: Have a pupil put on a pair of roller skates and stand on a smooth floor or sidewalk with feet parallel and close together. Be ready to catch the pupil if he falls! Throw one of the balls to a friend who is standing far enough away that he has to throw rather hard to reach him. Throw the ball. Measure the change in location of the thrower. Now throw several balls in succession. Note the distance travelled.

EXPLANATION: Throwing several balls, one after the other, illustrates the action-reaction principle which follows and it also illustrates the additional power produced by the several stages of a rocket. Stack three bricks on top of each other. Lift all three from the floor, drop the lower one. Ask "Does it require as much energy to continue lifting the remaining two bricks?" Continue to raise the bricks, dropping the second and third bricks.

OBSERVE: The decrease in weight and the fact that it becomes easier to lift the bricks as the weight is lessened.

2. Commercially produced models of rockets which are sold in stores may be examined to clarify the stages and their location. (Trained adults handle the firing of model rockets that operate by chemical fuels.) Check local laws and clear with authorities in control tower of local airport, etc.

TOPIC 4.15

(4-6)

All rockets work because of Newton's third law of motion, "For every action there is an equal and opposite reaction."

LEARNING ACTIVITIES

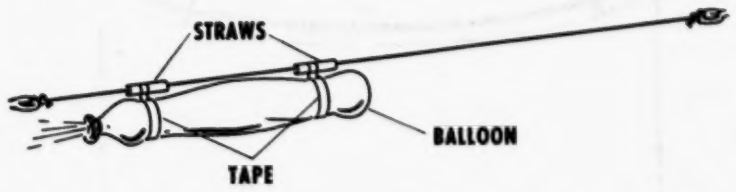
1. Observe a picture of a child swimmer in motion. The swimmer uses his muscles (force) to push the water backward. The backward push causes the swimmer to move in the opposite direction (reaction). The swimmer is pushed forward with as much force as he pushes backward. If he pushes back gently, with little force, he also moves forward with little force. So he moves slowly. If he pushes back with great force, he moves forward quickly.
2. Wind up a toy motor boat and note the action of the propeller. Allow a few drops of ink to fall behind the spinning propeller and note the water's movement.
3. Discuss the following phenomena which are explained by Newton's Third Law: a spinning lawn sprinkler, a moving bicycle, the backward movement of a boat when one steps into it, the kick of a gun when it is fired.
4. Illustrate action-reaction in sports. Depending upon the local interest in your area, encourage observation and recording of data on examples of action-reaction.
5. Students may observe the application of Newton's Third Law of Motion with a skateboard and two or three bricks. Have one student stand on a motionless skateboard on a smooth, level surface. Have the student hold the bricks in his hand. Now direct the pupil to throw the bricks one at a time in the direction he is standing. He will move in the opposite direction.

REINFORCEMENT

1. PROBLEM: How does a rocket work?

MATERIALS: Balloon, thread, soda straw.

PROCEDURE: Stretch a thread from desk to ceiling in a slanting fashion. Inflate a tube-shaped balloon. Fasten a soda straw to its side. Run thread through the straw. Hold the balloon mouth down at desk level and release. Note the direction in which the air escapes. Ask: "In which direction does the balloon shoot?"



EXPLANATION: For every action, there is an equal and opposite reaction.

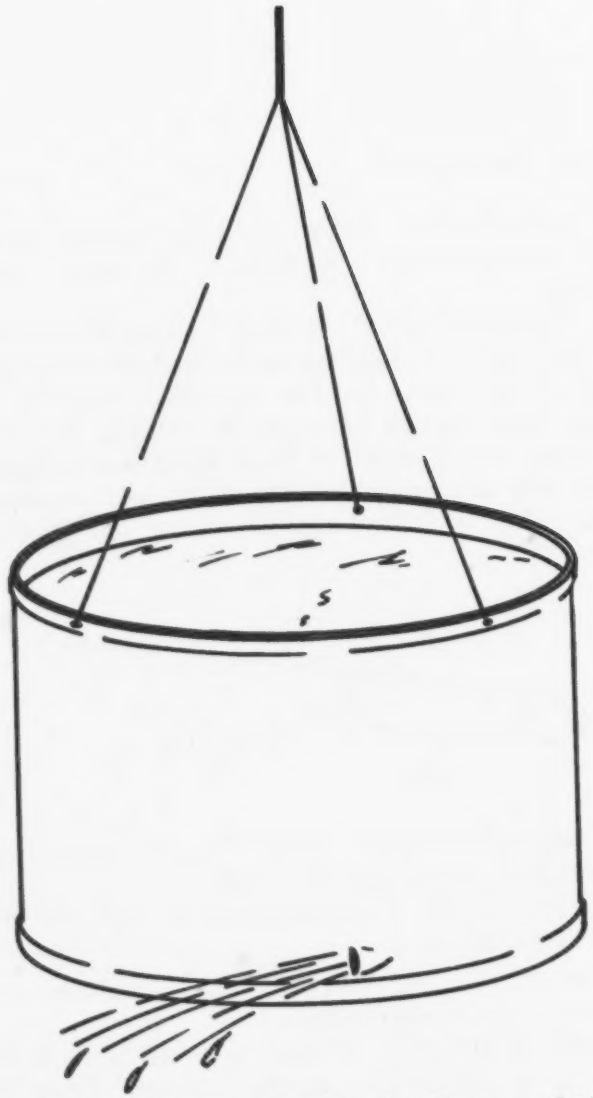
2. PROBLEM: Construction of an action-reaction engine.

MATERIALS: Water, cord, coffee can, hammer and small nails.

PROCEDURE: Punch a small hole in the side of a coffee can at the bottom. Bend the nail to the side so the water will pour out of the hole at an angle. Then remove the nail. Suspend the can by the cord so that it hangs evenly. Fill the can with water and observe the can as water leaks out.

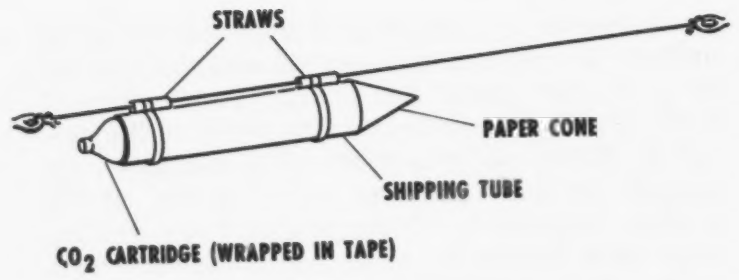
EXPLANATION: The water escaping acts as the source of action, causing the can to move in the opposite direction. (Note: This also should aid in illustrating how we change the attitude of a satellite by causing the propellant to escape, thus setting up an action-reaction situation.)

3. PROBLEM: Construction of an action-reaction engine.



MATERIALS: Block of balsa wood about 2'' x 2'' x 4'', two screw eyes, carbon dioxide sparklet (available at drugstores), 30 to 50 feet of fine wire or nylon fish line.

PROCEDURE: Curve one end of the balsa wood block to a bullet shape. Bore a hole in the other end just large enough to hold the carbon dioxide cartridge. Place the screw eyes at either end of the balsa block. Fasten the wire tightly across the room or in a hall. Hang the ''rocket'' so that the wire goes through the screw eyes. Puncture the CO_2 cartridge with a detonator and observe the motion of the rocket along the wire.



EXPLANATION: The escaping CO_2 is the source of action which causes the rocket to move in the opposite direction.

4. PROBLEM: Construction of an action-reaction engine.

MATERIALS: Nylon fish line, H_2O, small test tube with cork (Pyrex test tube from Science Laboratory), candle, ring stand.

PROCEDURE: Attach a soda straw to the side of the test tube and run the fish line through the straw. Place a tablespoon of H_2O in the test tube. Insert the cork, lubricated with vaseline, in the test tube. Heat the test tube with the candle, and note the effect on the tube as the cork pops out. The cork will fly out of the tube and cause it to move in the opposite direction.

EXPLANATION: This serves to further illustrate Newton's Third Law of Motion.

5. Spin a toy gyroscope and notice its resistance to a change of direction.

6. Read Isaac Newton, by Patrick Moore, Putnam, New York, 1958. (A biography of Newton with an account of his discoveries.)

TOPIC 4.16

(4-6)

Rocket engines carry their own propellant. They cannot rely upon oxygen from the surrounding air for combustion. Instead they carry their own fuel and also the materials to oxidize it, making it possible for them to function beyond the Earth's atmosphere. In rocket engines using solid fuels, the oxidizing material and the fuel are mixed together. They are stored and burned in the same place. In liquid-fuel rockets, the fuel and the oxidizer are stored separately and are mixed in a combustion chamber by means of valves. There they are ignited. Gas is produced and escapes at the rear, as in jets, thus providing thrust.

LEARNING ACTIVITIES

1. PROBLEM: How can we show how fuel is carried in a rocket engine?

MATERIALS: An empty pint milk carton, a length of thread, a toothpick, modeling clay, dry ice, tweezers, water, a paperclip.

PROCEDURE: Make a small hole in the center of the carton top with a paperclip. Put the thread through the hole. Tie the toothpick to the thread so that the stick will hold up the carton. Put clay around the thread at the hole so that there is no leak. Make a small hole with the clip in one side of the carton. Do the same on the opposite side. Pour water into the carton to a depth of about an inch, and suspend the carton so that it can turn on the thread. Use the tweezers to put two or three pieces of dry ice into the carton. DO NOT TOUCH THE DRY ICE WITH THE FINGERS. Close the cap tightly, and let go of the carton. The gas formed in the carton should escape and cause the carton to move.

EXPLANATION: Dry ice is solid carbon dioxide. The water in the carton gives enough heat to the solid to change it to carbon dioxide

gas. The gas should escape through the holes, thus illustrating fuel storage within the rocket. Additional activity: Ask the pupils to predict what might happen if two more jet holes are made in the carton sides.

2. PROBLEM: How can a simple rocket be constructed which illustrates a change from the solid to the gaseous state in the fuel?

MATERIALS: Paper matches, straight pin, aluminum foil, paperclip.

PROCEDURE: Place a paper match on a flat surface, then position a straight pin on the exposed flat side of the match with the point of the pin against the head of the match. Cut a strip of aluminum foil wide enough to wrap around the match and long enough to fold back over the head of the match to provide a double thickness completely over and around the matchhead. Carefully remove the straight pin, taking care not to disturb the channel made by the pin. Bend the paperclip so as to form a stand for the match. Place the matchhead uppermost on the launcher. Hold a lighted match under the head of the foil-wrapped matchhead. The rocket should take off as soon as the chemicals on the matchhead are hot enough to change from a solid to a gaseous state.

EXPLANATION: When the chemicals on the matchhead change from a solid to a gaseous state, expansion takes place. The expanding gases are forced to escape through the restricted channel, forcing the rocket to be propelled into the air.

REINFORCEMENT

1. PROBLEM: Cooling rocket engines

MATERIALS: Water, candle, paper cup

PROCEDURE: Pour water in the cup and place it over an open flame. Let the water boil and note what happens to the cup. Allow the water to boil until it has boiled dry and note what happens. (The cup burns)

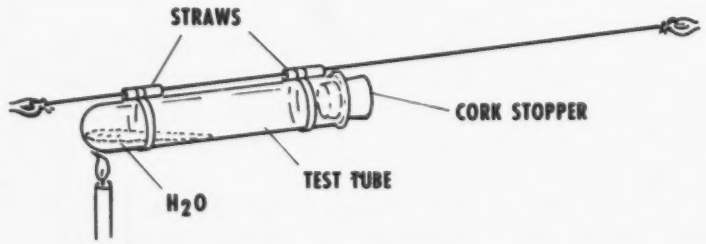
EXPLANATION: Excessive heat damage can be reduced by the circualtion of liquids through the heated surfaces.

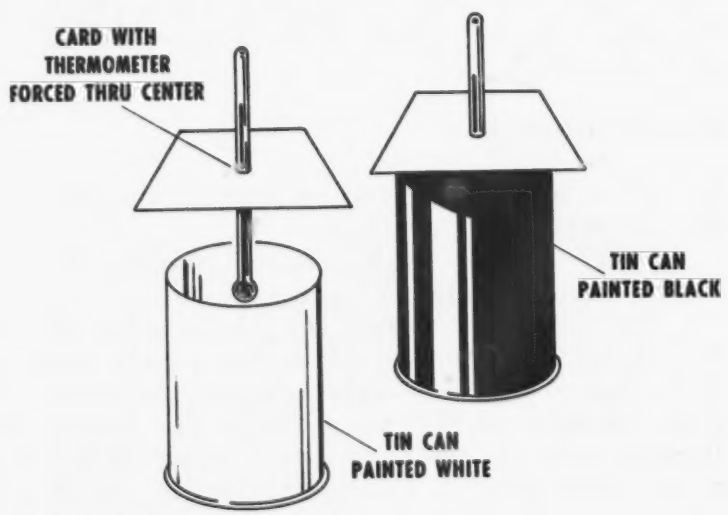
2. PROBLEM: Temperature control in rocket vehicles

MATERIALS: Two tin cans, two lab. thermometers, paint (black and white), heat lamps, two pieces of light cardboard.

PROCEDURE: Paint one can white and the other black. Suspend thermometers in the cans, through the holes cut in the cardboard; bulbs must not touch the cans. Direct the heat lamps at cans so that the rays shine directly on the cans but not on the thermometers. Record the different temperatures.

EXPLANATION: The white can reflects the radiant energy and the black can tends to absorb the radiant energy and change it into heat. One method of temperature control in rocket vehicles is by using various paint patterns of color.





TOPIC 4.17

(4-6)

Rockets are often launched toward the East because the East is the direction of the Earth's rotation.

LEARNING ACTIVITIES

Use cellophane tape to attach a small cardboard cutout of a rocket to a globe of the earth. Spin the globe from west to east in the direction of the earth's rotation, and show how the earth's speed of rotation gives the rocket an extra push of about 1000 miles per hour. This aids the rocket in reaching the speed it needs for insertion into orbit.

REINFORCEMENT

Have the students find out why some launch vehicles are used to put satellites into a north-south orbit.

Did they find that the TOS (Tiros Operational System), a joint NASA-U.S. Weather Bureau program, used a north-south orbit in order to have the Tiros satellites in a near-polar orbit? This orbit permits the satellite to provide complete photographic coverage of the earth compared to the 25% coverage provided by earlier Tiros craft.

Did they find that Nimbus also is placed in a near circular polar (traveling north and south) orbit?

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NF-8 Launch Vehicles.
NF-20 U.S. Launch Vehicles (Color supplement to NF-8)

Films:
"The Dream That Wouldn't Down;" 1965; NASA HQK-125; sound, black and white, 26:38 min.
"Father of the Space Age;" 1961; NASA HQa-54; sound, black and white, 18 min., grades 5-adult.
"Saturn Propulsion Systems;" 1962; NASA HQa-77, sound, color, 14 min., grades 6-interested adults.
Filmstrip:
"Don't Build That Rocket Alone;" 1966; NASA; record, tape recording, handbook, 64 frames.

TOPIC 4.18

(4-6)

As the spacecraft passes through denser air on its return to the earth, it glows red hot from friction and the compression of the atmosphere. To prevent destruction, its forward end is fitted with a "heat shield" which gradually ablates.

LEARNING ACTIVITIES

1. Demonstrate heat caused by friction by having the class take part in the simple experiment of rubbing the hands together.
2. Demonstrate air resistance by having several children run with a square of paper held flat against the wind and then with the edge against the wind. Note the difference in resistance.
3. PROBLEM: Friction and its influence on a moving object.

MATERIALS: Aquarium with water, pebble.

PROCEDURE: Toss the pebble at a slant into the water. The pebble strikes the water and slows down. The pebble is slowed by the friction of the water. It gradually drops to the bottom.

EXPLANATION: This can be related to the re-entering spacecraft as follows: The air particles of the atmosphere cause the satellite to slow down and therefore aid in bringing it back to earth.

4. Children should observe the shape of the spacecraft by inspecting a model. Note the cone shape. Re-entry of the craft is made with the blunt end down. Most of the friction occurs on this surface.

REINFORCEMENT

1. PROBLEM: Illustration of the reason for the shape of the spacecraft.

MATERIALS: Paper cone, plaster-of-Paris, large container of water.

PROCEDURE: Form a model spacecraft by filling the paper cone with plaster-of-Paris. When the plaster-of-Paris hardens, push the cone, pointed end first, through the water. Ripples will be seen along all sides of the cone. Now push it through the water, blunt end first. The ripples form chiefly at the blunt end and are pushed away from the rest of the surface. Assume that the ripples are the places where there is friction with the atmosphere and, hence, where heat is produced.

EXPLANATION: This illustrates how a properly shielded blunt end of the spacecraft protects the vehicle from the heat produced during re-entry.

2. PROBLEM: To illustrate one of several methods for protecting a spacecraft.

MATERIALS: One ice cube, small thermometer, book of matches.

PROCEDURE: Freeze the thermometer into the ice cube. Hold the thermometer end in your hand and heat the ice cube with matches. Tip the ice cube up so the melting water will run down the thermometer stem and not drip into the flame. Observe the temperature change that occurs when the ice cube is heated. Note what happened to the "heated" portion of the ice cube.

EXPLANATION: The heat shield melts away as the spacecraft re-enters the earth's atmosphere, thus absorbing most of the heat caused by the friction and compression and allowing the spacecraft to remain relatively cool.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA, SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.
NF-23 Manned Space Flight: Apollo.
Films:
"Flight of Faith Seven, The;" 1963; NASA HQa-101, sound, color, 28 1/2 min., grades 5-adult.
"The Shape of Things to Come;" 1965; NASA HQ-106, sound, color, 20 1/2 min., grades 6-adults.

TOPIC 4.19

(4-6)

As we travel farther away from the earth the atmosphere becomes thinner. The cabin of the spacecraft must be pressurized to protect the astronaut. If the astronauts are not protected by their pressure suits and/or the cabin being pressurized their body fluids will boil. Boiling of the body fluids occur when the pressure is not sufficient to keep the gases in the fluids in suspension. If the cabin pressure system fails the astronauts spacesuit can be automatically pressurized.

LEARNING ACTIVITIES

1. To illustrate the fact that the atmosphere is different at higher altitudes, discuss the following experiences with the pupils: Perhaps some of the children have been in the high mountains and can talk with the other class members about the difficulties of breathing at high levels. Some may be able to give an example of other problems which are typical such as the nose bleed (due to the pressure being higher inside their bodies) and trouble with the car motor due to higher altitudes. Even experiences in the elevators of tall buildings may be used.
2. If possible secure a copy of a flight log from a commercial airline. This will show differences in pressure and temperature at the high altitudes at which some of the planes fly. If any pupil has flown at high altitudes he might be able to discuss the adjustments which have to be made so that the passengers are comfortable while riding at high levels, and also the discomfort that follows a rapid change in pressure.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

TOPIC 4.20

(4-6)

An artificial satellite is simply a man-made object revolving about the earth. It obeys the same laws the natural moon and the planets obey in their revolutions. The speed necessary for a satellite to go into orbit close to the earth is about 18 thousand miles per hour. Farther from the earth the orbital speed of a satellite is less. The velocity of a man-made satellite in orbit must be such that its altitude, its speed and direction of travel combine to withstand the pull of gravity from the earth.

Escape velocity is about 25 thousand miles per hour.

LEARNING ACTIVITIES

1. Coasting on a bicycle or on a sled or skis is a familiar experience to many children. Encourage individual or teams to invent ways to show how coasting may occur in space. A simple illustration of the coasting analogy involves pushing a tennis ball off the edge of a table. Stand to the side and observe how the ball drops almost straight down. Repeat, giving the ball a shove which makes it travel in a curved arc as it falls. Relate this activity to the speed of an orbiting space craft around the earth.
2. Set a globe beside a model of a spacecraft. Have the pupils list the similarities: both are spinning in space (because of the inertia of motion) and both are traveling in a closed curve.

REINFORCEMENT

Encourage the pupils to read and report on science fiction concerning space craft and space exploration. Comment on the difference between the facts we know and fiction as was written in the recent past.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA, SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: $.25.

TOPIC 4.21

(4-6)

If a satellite moves fast enough, it is not pulled down by the earth's gravity. Both the moon and artificial satellites are going very fast and can stay out in space, but if they slow down at all the earth's gravity will begin to pull them toward the earth. Gravity causes the satellite to fall just enough to prevent its flying off into space. The object is then said to be in orbit. Most satellites travel in an oval (elliptical) orbit, while others travel in a near-circular orbit. Rockets push satellites into space fast enough and far enough so that they are not pulled back immediately to earth by gravity.

LEARNING ACTIVITIES

1. Suspend a ball attached to a string so that it hangs almost to the floor. Observe that it hangs straight down. Ask "what makes it hang down toward the earth?" (The pull of gravity) Now make the ball go in a circle. The ball rises higher off the ground. The earth's gravity is still pulling down, but the ball has moved up a little. Make the ball go faster and faster. It will go higher and higher. Observe that the ball stays up if it keeps moving fast. Now allow it to slow down; the earth's gravity will pull the ball down again. (The satellite is not attached to a string but receives the initial speed from a launch vehicle.)
2. Have the pupils twirl a ball tied to a string around their heads. Vary the length of the string and notice the varying amount of speed needed to keep it in orbit. Release the string and notice the direction in which the ball travels.
3. Repeat experiment number 2. and observe the shape of the orbit.

REINFORCEMENT

1. Suggest that the pupils think of the swings in an amusement park which hang down when still but the swings move out and up more and more when the ride is started. Even though they do not swing out straight, they do help to make the above concepts more meaningful.
2. Use Newton's original analogy to help explain how an object could be put into orbit. Ask "what would happen if you threw a ball sideways very hard from the top of a mountain?" (The ball would fall part of the way down the mountain.) If you could throw a ball much harder, considering the curvature of the Earth, it might keep on falling. It might fall around the Earth and become an Earth satellite. Rockets give a satellite a push so that it can fall around the Earth. (Approximately 18,000 miles per hour for manned spacecraft is called the orbital velocity.)
3. PROBLEM: How do different kinds of force change the path of a falling object?

   MATERIALS: Small ball, table

   PROCEDURE: Place a small ball near the edge of a table. Tap it lightly so that the ball falls to the floor. Mark the spot on the floor where the ball hit. Continue the demonstration by striking the ball with more and more force and recording the landing spot each time. Ask "how did the paths of the three balls differ?" "How did the marks on the floor differ?"

   EXPLANATION: The ball will fall farther and farther from the table as the force increases. The path that a falling object follows depends upon the push given to it.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA, SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: $.25.

TOPIC 4.22

(4-6)

The astronaut experiences stress upon acceleration and deceleration of the spacecraft. The rapid acceleration necessary to reach the speed for orbiting the earth and for escape from the earth puts a crushing pressure on the astronaut. He experiences this pressure again as the spacecraft, slowed down by the thickening atmosphere, returns to earth. The spacecraft is constructed so that it can absorb as much shock as possible upon landing.

LEARNING ACTIVITIES

1. PROBLEM: Deceleration of spacecraft.

   MATERIALS: One roller skate, brick, string, shoe box, rag doll.

   PROCEDURE: Seat a doll at the back end of a shoe box which has been tied to a roller skate. Give the skate a push so that it will roll across the table and hit a brick. Repeat the experiment with the doll sitting with its back against the front end of the box. Note the difference in what happens to the doll in the second collision compared with the first.

   EXPLANATION: A sudden and drastic change in velocity imposes great stress (g-force) on a moving object. In the spacecraft, the position and design of the astronaut's couch helps him withstand the forces of deceleration and acceleration.
2. PROBLEM: Illustration of normal flow of blood as opposed to the abnormal flow which results from acceleration and deceleration.

   MATERIALS: Several students.

   PROCEDURE: Ask the children to compare the color of the palms of both hands. Have a pupil swing his right arm in a circle. Tell the students to continue to swing the arm until he feels a sensation of pressure in his hand. Compare the color of his palms. Note the change in color of the right hand.

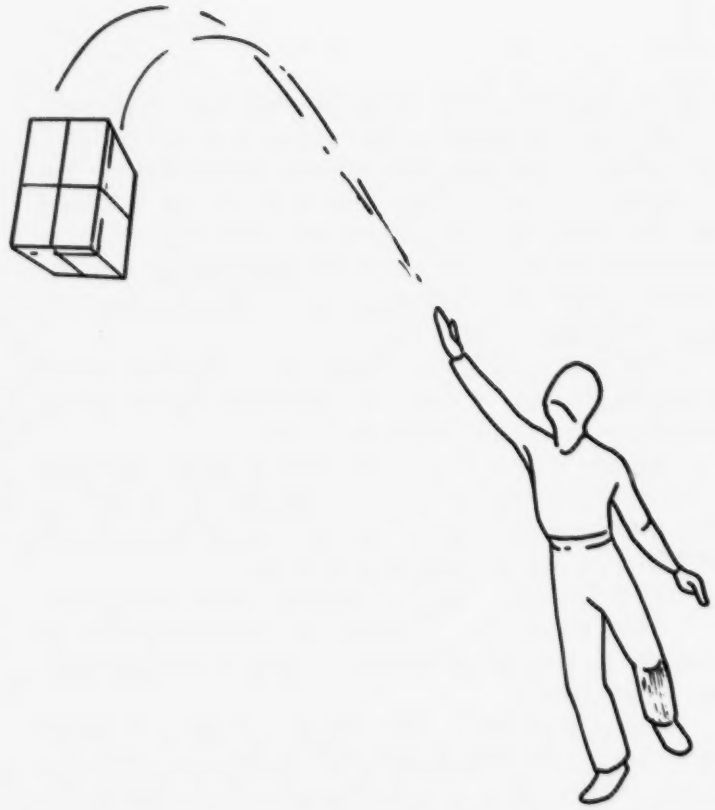
   EXPLANATION: Swinging the arm causes blood to be forced to the hand as a result of centrifugal force. The excess blood causes the palm of the hand to look pinker than the other palm.

3. PROBLEM: Pressure may change materials.

MATERIALS: A handful of soil or snow.

PROCEDURE: Make a ball of damp soil or snow, packing it together firmly so that it just holds its shape. Toss it up and let it fall on hard ground. What happens? Does the ball flatten out?

EXPLANATION: Astronauts have the same type of experience in taking off and landing, and must avoid being "flattened out". To withstand this pressure, measured in g's, the body is cradled and held on a chair or couch molded to fit the astronaut. This distributes the pressure as evenly as possible.



REINFORCEMENT

1. PROBLEM: Air exerts pressure.

MATERIALS: Milk bottle, peeled hard boiled egg.

PROCEDURE: Place some paper or a candle in the bottle and light it. After the paper has burned for several seconds, place the egg in the mouth of the bottle. The egg moves up and down for a moment and then drops into the bottle.

EXPLANATION: The air pressure in the bottle decreases because the burning paper causes the gases in the bottle to expand and escape before the egg is placed on the bottle. Thus the egg is forced into the bottle.

2. PROBLEM: Shock absorption in spacecraft.

MATERIALS: A number of boxes, lined with foam rubber, paper, wood, a variety of materials.

PROCEDURE: Package an egg. Drop the egg from belt level to the floor; examine the egg. Increase the height to eye level and drop several boxes again. Record the results. Drop each box from over the head; check effects. Continue increasing the height until the best shock absorption material has been found.

EXPLANATION: A variety of materials can be used to absorb the shock of hard landings.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Film: "The Four Days of Gemini Four;" 1965; NASA, HQa-134; sound, color, 28 min., All grades.

TOPIC 4.23

(4-6)

The astronaut needs protection to preserve his life in the environment of space. The astronaut is normally protected by the blanket of atmosphere that surrounds the earth, but in space, unless there is adequate protection, the astronaut will be scorched by ultraviolet rays from the sun.

The extreme intensity of light in space often requires the use of mechanical aids to enable astronauts to see.

By leaving earth from a region near the North or South Poles the astronauts may avoid the belt of trapped particles known as the Van Allen Belt, or in more general terms, the magnetosphere. We must protect the astronauts from exposure to harmful radiation. Consideration must also be given to possible collision with micrometeoroids.

ASTRONAUT HELMET WITH SUNSHIELD

LEARNING ACTIVITIES

1. Invite the nurse to discuss the physiology of sunburn, using information to show what acts as a shield.
2. Shine a desk lamp (representing sunlight) on one side of an object such as a circular piece of cardboard. How does each side of the object feel? The side of an object nearest the sun absorbs heat more rapidly than the other side.
3. PROBLEM: Some materials shield against ultra-violet radiation better than others.

MATERIALS: Ultra-violet light source, ring stand, 3-ring clamps, fluorescent minerals, soap flakes, or powders and fluorescent paint work well.

PROCEDURE: Secure an ultra-violet light, and the fluorescent materials and place in a dark room. Place the fluorescent materials as close as possible to the light to increase intensity of the glow, allowing space in between to place various objects and media. This is best set up vertically since then liquids can be included. Try glass, plastics of various thicknesses, aluminum foil, smoke, etc.

4. PROBLEM: Astronaut's eye protection.

MATERIALS: Flashlight (2-cell only), mirror, various colors of cellophane, felt tip marker.

PROCEDURE: Directions for students - Look at the pupils of your eyes in the mirror. Cover one eye while observing the pupil of the other eye. Move the flashlight so that it shines into one eye at an angle. Move it away quickly. Observe the action of the pupil. Repeat, moving the light back and forth quickly. Try this on another person and observe the reaction of their pupils. Now try using the different colors of cellophane and make a filter for the flashlight. Repeat the above procedures for shining the light into the eye. Print a word on the lens of the flashlight with the felt tip marker. Determine the cellophane color which, when used as "sunglasses", allows you to read the word most easily.

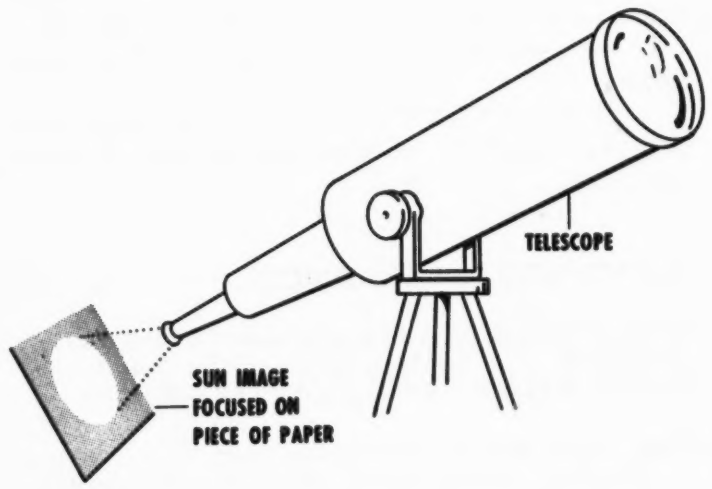
EXPLANATION: The astronauts wear sunshields in order to protect their eyes during extra-vehicular activity.

As an added activity in this area, discuss possible methods which might be used to provide protection for the astronaut's eyes and still allow for greatest visibility.

5. PROBLEM: Solar storms, space hazards.

MATERIALS: Telescope and stand (reflector type), white sheet of paper, Directions for Students.

PROCEDURE: DO NOT LOOK AT THE SUN WITH A TELESCOPE. Just as you could burn a hole in a piece of paper, you can burn the retina of your eyes, causing blindness. Take the telescope and focus it on the most distant object visible, e.g., the horizon, the moon, BUT NOT THE SUN. Once focused, point the telescope at the sun by watching its shadow on the ground-NOT BY LOOKING THROUGH IT AT THE SUN. Now, hold a piece of paper a few inches from the eyepiece and re-position the telescope until a 2" or 3" image of the sun appears on the paper. Don't make the image smaller because by doing this it becomes too bright. Finally, focus the eyepiece so that a sharp, clear image is formed.



Examine the image on the paper. Small black dots may appear on the image which are sun spots on the surface of the sun. Some large spots measure up to tens of thousands of miles in diameter.

EXPLANATION: These are violent erruptions on the sun. Because they are cooler than the surrounding areas, they appear darker. These erruptions send out deadly radiation which reaches the earth in 8 1/2 minutes and streams of particles which arrive a day later. We observe the effects of large spots as northern lights and communication disruption.

REINFORCEMENT

1. PROBLEM: Illustration of the alignment of the earth's magnetic field.

MATERIALS: Iron filings, sheet of cardboard, pane of glass, and horseshoe magnet.

PROCEDURE: Directions for Students - Sprinkle iron filings on a sheet of cardboard or on a pane of glass. Lay the card or glass on a horseshoe magnet. Tap the card or glass lightly and note evidence of the direction of the lines of magnetic force around the poles

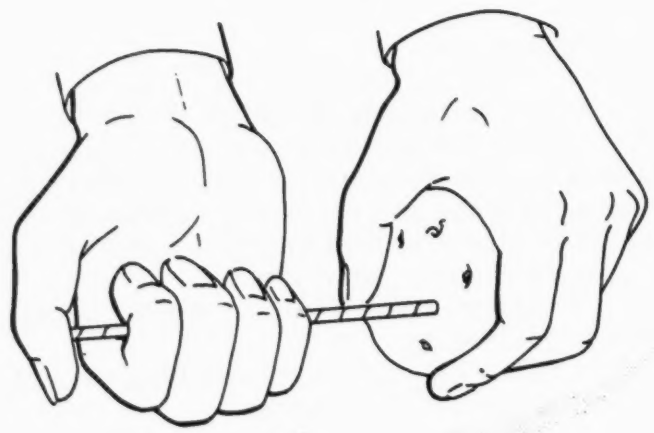
of the magnet. What effects do you observe in the alignment of the filings?

EXPLANATION: The filings line up along the magnetic lines of force, extending from one pole of the magnet to the other.

Additional activities: Draw a diagram of the earth's magnetic field. Draw the Van Allen Radiation Belt.

2. PROBLEM: Micrometeoroids-space hazards.

MATERIALS: Paper straw and plastic straws of different sizes; raw potato.



PROCEDURE: Directions for pupils - Hold the potato in your hand (between the thumb and index finger). Do not hold it in the palm of your hand. With the straw in the other hand, try to drive the straw through the potato. If after a few tries you have no success, try covering the end of the straw with your thumb in order to trap an air column. Just before you attempt to pierce the potato with the straw, bring the potato quickly toward the straw. Repeat, using different sizes of straws.

EXPLANATION: Because small particles travel through space at tremendous speeds, they are easily able to penetrate a spacecraft. Additional related activity: Relate this activity to particles traveling in space. How do size and speed affect the ability of the straw to penetrate the potato? Devise methods by which the spacecraft might be protected from meteoroids traveling in space.

3. PROBLEM: Micrometeoroids-space hazards.

MATERIALS: String (3 ft. to 4 ft.), strong U-magnet, microscope.

PROCEDURE: Directions for pupils - Attach the string to the magnet. Drag the magnet across the lawn or field, allowing the magnet to collect any material that might be attracted to it. Observe the material collected-about 5 to 10 per cent will be meteoric. Observe some of the particles under a microscope. Note the kinds of structure.

EXPLANATION: Meteoric material is a danger to the spacecraft and to the astronaut. This demonstration illustrates the frequency of meteoric material found on the earth and around the earth.

Additional Related Activity: Investigate the material found near the downspouts of the school; this too contains micrometeoric material.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

"Freedom Seven;" 1961; NASA, HQ-STG 51, sound, color, 28 1/2 min., grades 5-adult.

"America in Space;" 1963; NASA HQ-103; sound, color, 14 min., grades 5-adult.

TOPIC 4.24

(4-6)

An astronaut's space suit is equipped with his own conditioning system. This system operates automatically when needed to perform certain functions. The space suit is coated with aluminum or other materials to reflect heat.

LEARNING ACTIVITIES

The following three demonstrations illustrate the fact that evaporation of a liquid causes cooling. This same principle can be applied to a space suit and to a manned spacecraft.

1. Rub water on a large area of the hand or arm, fan the wet area and note the results.

2. Tie a piece of gauze around the bulb of one thermometer and wet it. Place the thermometers side by side. Direct a fan at them. Observe the results.

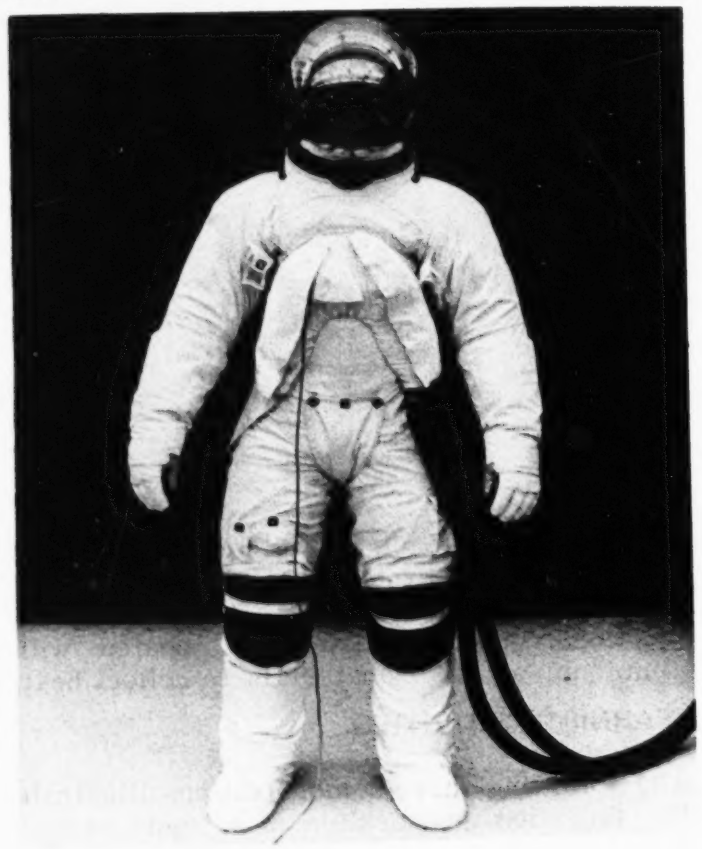
3. Rub water on the back of one hand and alcohol on the back of the other. Hold the fan over each. Note and record the apparent difference in temperature.

4. PROBLEM: Astronaut clothing.

MATERIALS: One brown paper bag, one metallic ice cream bag, two thermometers, ice cubes, string.

PROCEDURE: Place several ice cubes in both the brown paper bag and the metallic ice cream bag. Place the thermometers in each. Seal the tops. Note the temperature in both bags after several minutes. (The shiny bag remained cooler.)

EXPLANATION: The shiny bag is cooler because the exterior heat is reflected.



REINFORCEMENT

1. Obtain identical tin cans. Paint one black and leave one shiny. Place a thermometer in each through a hole in the center of a piece of cardboard. Place in the sunlight for ten minutes. Read the thermometers. (Black surfaces absorb radiation and change it into heat. Shiny surfaces reflect radiation.)
2. Discuss the clothes worn during the various seasons and those worn by the astronauts.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA; Project Gemini; Supt. of Doc.; Price: $.45.
Film:
"Suited for Space;" 1966; NASA, HQK-SR5, sound, B&W, 28 1/2 min. Grades 5-Adult.

TOPIC 4.25 (4-6)

After the ascending spacecraft has reached orbiting height, the astronaut will not feel the normal pull of gravity. He will be in the state sometimes called "zero gravity". The mass of matter that forms his body is unchanged. His weight has been completely neutralized by a counteracting force. The effects of weightlessness are being studied. Astronauts are testing some of the interesting consequences: Objects in the cabin no longer fall to the floor, but float along while in orbit. The astronaut, too, can float in mid-air if he loosens the straps that hold him in his seat. His reactions resemble those of a frogman in a tank of water. Astronauts have left the spacecraft several miles from the earth. When they did this, the problem of zero gravity became even more apparent.

LEARNING ACTIVITIES

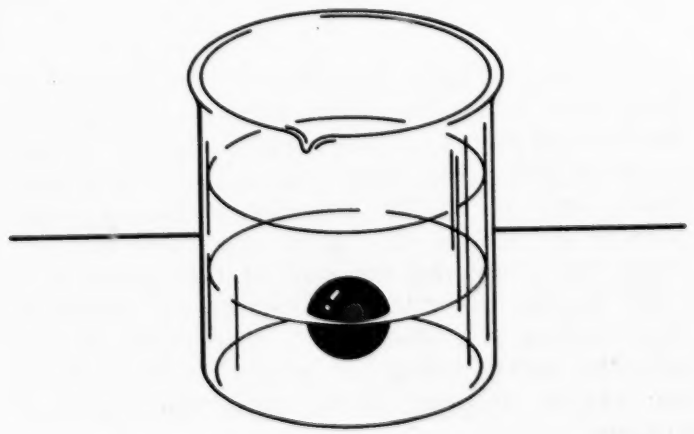
1. Have the pupils experience weightlessness to a small degree by taking part in the following: Ride in a swing. Notice the feeling at the end of the arc. Notice how heavy one feels at the bottom of the arc.
2. Ask one pupil to hold a book in one hand. Notice the weight of the book. Now, tell the pupil to drop the hand with the book. The book for a moment seems to weigh much less. Explanation: A falling object seems to weigh very little when the platform on which it rests is falling at the same rate.
3. If a child stands quietly on the scales, they may show that he weighs one hundred pounds. Now, ask the pupils to suppose that the scales are placed in an elevator and the child stands on them while the elevator starts to rise rapidly. For the moment, the scales may indicate twice the normal weight of the child, or two hundred pounds. A space expert would say he has experienced an acceleration of "2 g's" or twice the normal pull of gravity. If the elevator should descend rapidly enough, the child's apparent weight might drop to zero. He would then be said to be in a state of weightlessness, or "zero gravity".

REINFORCEMENT

1. To illustrate that weight is a measure of gravitational attraction between an object and the earth, discuss the mountain climber who travels up a mountain. Gravity decreases because the distance from the center of the earth is greater and thus he weighs less.
2. PROBLEM: Problems of weightlessness-handling of liquids.

MATERIALS: Olive oil, rubbing alcohol, pencil, beaker (250 cc), water.

PROCEDURE: Fill the beaker about 1/4 full of water. Add a few drops of olive oil,



making sure that the oil is together and not scattered. Add alcohol very slowly, using the pencil until the sphere of oil appears to be suspended in the water and alcohol solution. Take a pencil and break up the oil globule into many smaller ones. Notice the shape they immediately assume.

EXPLANATION: Liquids behave differently in a weightless condition.

3. The following activity is concerned with the ways by which man is attempting to cope with the problems of weightlessness: Ask the pupils to try to think of a possible solution to this problem. Stand facing a wall two or three feet away and push away from the wall with both hands. Does your body move? Do your feet move? The extent of your body movement is limited by the pull of gravity. What would happen if you were on the outside of a spacecraft several miles from earth and were to push against the side of the craft?

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Film:
"Step Into Space;" 1965; NASA MSC 65-259; sound, color, 11 min., grades 5-adult.

TOPIC 4.26

(4-6)

The Moon is the closest object in space to the Earth. Scientists of many disciplines are anxious to study the Moon. The Moon is only the first stage in extraterrestrial exploration. The astronauts must have as much information as possible before they go to the Moon.

LEARNING ACTIVITIES

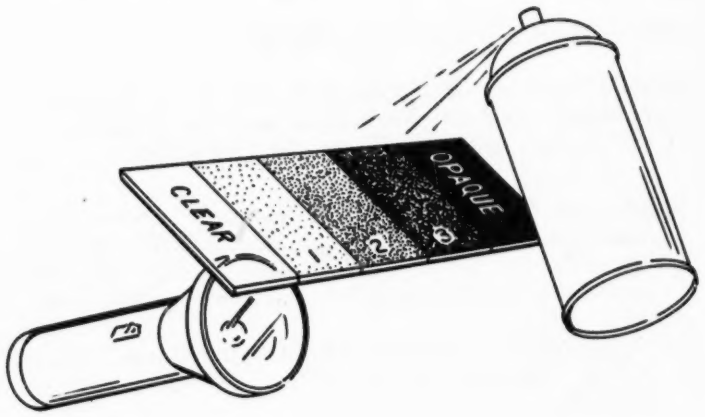
1. It is possible to demonstrate the lack of an atmosphere on the Moon by the principle of occultation.

MATERIALS: Flashlight, roll of wax paper or white paint (Krylon spray), dictionary, 12'' x 18'' window glass.

PROCEDURE: The wax paper may be taped to the glass. Vary the number of layers until one strip is opaque. (Spray paint may be used to make a permanent demonstration apparatus.) Place the light so that it illuminates an object behind the glass. The light represents the sun. Observe object first by looking through the divisions of the various densities of paint or wax paper.

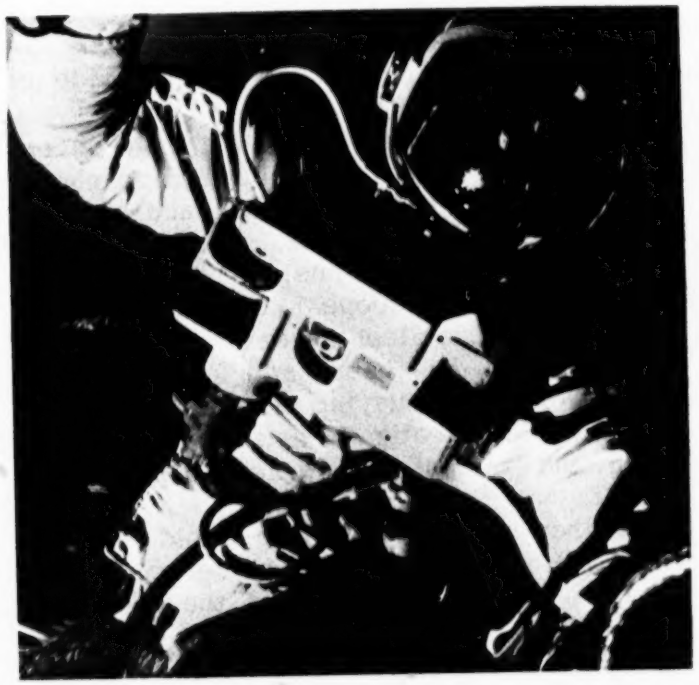
After defining occultation, the students should be able to demonstrate how we are able to determine if the Moon has an atmosphere. You may wish to pose the question: "Which section of the glass represents the atmosphere of the Moon and what could the other densities represent?". Since the Moon lacks this blanket or atmosphere and if the earth were like the Moon, the part of the earth that faces away from the sun would become very, very cold.

The side of the Moon that has the sun shining on it is very, very hot, but the dark side is very cold.



2. Students are familiar with the use of sun glasses to protect our eyes from the ultraviolet rays from the sun. Once they realize that the intensity of the sunlight will be much greater in space, they will see the need for special devices to protect the astronaut's eyes when he is doing a space walk or exploring the Moon.

White's Space Walk



Notice the glare on Astronaut White's face visor during his historic Extra-Vehicular Activity (EVA) during the Gemini Titan Four (GT-IV) flight. The special visor has a layer of gold to protect his eyes from the intense sunlight.

REINFORCEMENT

Most scientists agree that there can be only traces of the gases common to the Earth's atmosphere in the lunar atmosphere. Nitrogen and oxygen are the important possibilities. Even smaller amounts of hydrogen, helium, and water vapor could be expected. Spectroscopic studies are made of the lunar atmosphere. The measurements have been made from the Earth. During future lunar exploration programs, spectroscopic studies will be made on the surface of the Moon.

Once the students realize that the apparent twinkling of stars is caused by an atmosphere, they will recognize the significance of being able to get beyond our atmosphere to make astronomical observations. Some might even suggest that a telescope located on the Moon would be an excellent observatory situation.

Occultation has been used for a long time as a method of studying the stars. Students may wish to investigate the relationships between the terms: occultation, eclipse, and transit.

1. Without an atmosphere to shield the lunar surface from the sun's light energy, discuss some of the implications of the following:
   a. Shadows
   b. Photography
   c. Space suit temperatures
   d. Spacecraft temperatures
   e. Characteristics of the lunar surface
   f. Colors
2. What is meant by "albedo" and how does the Earth's albedo compare with that of the Moon's?
3. What scientists other than astronomers might be interested in going to the Moon for scientific studies?
   a. Geologists
   b. Biologists
   c. Chemists
   d. Physicists
   e. Mathematicians
4. Make a list of information other than about the lunar atmosphere that astronauts need to know when they go to the Moon. Groups of students may wish to choose topics for a research project and report on them to the class.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA, SP-7; Dictionary of Technical Terms for Aerospace; 1965; Supt. of Doc.; Price: $3.00.
NASA, SP-126; Surveyor I, A Preliminary Report; Scientific and Technical Information Division; 1966.
Film:
"Project Apollo - Manned Flight to the Moon;" 1963; NASA HQ 455; sound, color, 13 min., grades 6-adult.

5. Science: Junior High School

by Dorothy J. Kunde

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Science: Junior High School

TOPIC 5.01

(7-9)

A satellite remains in its orbit because of two physical phenomena: inertia and gravity. Inertia is the tendency of a moving body to continue to move in a straight line unless something interferes to change its motion. Gravity pulls a spacecraft into orbit around the earth. Satellites are not slowed by friction because there is almost no atmosphere to cause friction in space.

LEARNING ACTIVITIES

1. PROBLEM: Demonstration of the forces acting on a satellite.

MATERIALS: Five metal washers, 40-inch length of string, large wooden spool.

PROCEDURE: Push the string through the hole in the spool. Tie four of the washers to one end of the string. Tie one washer to the other end. Hold the spool in your hand and whirl the single washer in a circle. The four washers should hang down from the bottom of the spool.

EXPLANATION: The single washer represents an orbiting satellite. The weight of the four washers and the string connecting them with the single washer prevent the single washer from flying off in a straight line as it circles. The string represents the gravitational pull of the earth.

2. PROBLEM: Demonstration of inertia.

MATERIALS: Shoe box, ball, table.

PROCEDURE: Remove one end of a shoe box and place a ball in the box. Move the box, with the open end forward, along a long table. Now stop the box suddenly after it has traveled about one third of the distance across the table. The ball continues to roll in a straight line.

EXPLANATION: The inertia of the ball will make it continue to travel in a straight line across the table top.

3. Have the children recall what happened when a car in which they were riding stopped suddenly. (Their bodies which were in motion continued to be in motion, they snapped forward; that is, they remained in motion.)

REINFORCEMENT

1. Further demonstration of the everyday experiences which might illustrate straight line inertia of motion are bowling and golf.
2. PROBLEM: Illustration of the forces of gravitation and inertia

MATERIALS: Bicycle, assorted small objects

PROCEDURE: Lay a bicycle on its side. Lay small objects on the sidewall of one tire. Spin the wheel, the objects fly off in a straight line. Point out that the satellite curves around the earth because of the gravitational pull of the earth.

EXPLANATION: This is a good example of inertia of motion. The demonstration is explained above during the progress of the lesson.

3. Notice how the water is thrown off the wheels of a passing automobile, or stand a bicycle upside down and have a child turn one of the wheels while another pours a few drops of water onto the tire. If the wheel spins fast enough, drops of water will fly off the wheel at a tangent, or parallel to the wheel. They move away from the wheel along the inertial path due to inertia.
4. PROBLEM: Illustration of the Laws of Inertia and Gravitation

MATERIALS: Tennis ball, string

PROCEDURE: Tie a string around a soft ball, such as a tennis ball. Ask what will happen if you swing the ball around your head and let it go: why does it fly off in a straight line? (Law of Inertia) Ask why a spacecraft does not fly straight into space?

EXPLANATION: The Law of Gravitation plus the fact that retrorockets, attitude thrusters, and navigational devices make use of the laws of motion, keep the craft in a carefully computed course.

5. PROBLEM: Why do satellites not slow down and stop? The following experience will cause the pupils to think about friction and its importance to us on the earth and conversely the lack of friction and its importance in the space program.

Ask the pupils to think about motion here on the earth. When you run and slide on the ice you will probably slide for a distance but eventually slow down and stop. When you roller skate you may roll for a time, but you soon have to push yourself again to keep moving.

EXPLANATION: On the earth friction slows your movement. There is friction between the shoes and the ice and friction between the roller skates and the ground. In space there is very little for a satellite to rub against since space is almost empty.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: $.25.

Film:

"Celestial Mechanics and the Lunar Probe;" 1958; NASA HQa-26, sound, color, 10 1/2 min., grades 7-adult.

TOPIC 5.02

(7-9)

Most earth satellites have orbits which are oval shaped. The point fartherest from the earth is called apogee. The point in the orbit nearest to the earth is called perigee.

LEARNING ACTIVITIES

1. One way to observe how an ellipse or oval and a circle are formed is to look into a drinking glass that is about one third full of water. Note that the water makes a circle where it touches the inside of the glass. Now tip the glass, note the change in the shape of the water as it touches the sides of the glass. Ask the pupils to tip the glass more and to observe the changing shape of the water.
2. PROBLEM: Observation of an object orbiting in an ellipse

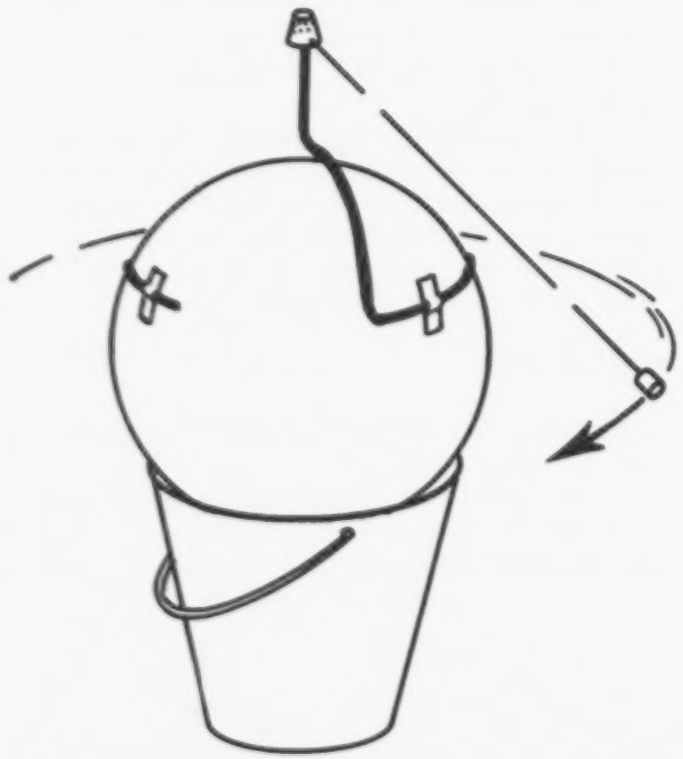
MATERIALS: Take a new pencil and stick two large pins into it at right angles about four inches apart. Tie the thread into a loop so that it is just a little longer than the distance between the pins. Before the knot is tied, put the thread through a ring. Hang the ring and loop over the two pins. Have a pupil hold the pencil upright and orbit the ring around the pins. (An up and down motion of the pencil combined with a circular motion is required to move the ring.)

EXPLANTION: When the ring is orbiting, the shape of an elliptical orbit can be observed.

REINFORCEMENT

1. PROBLEM: Satellite orbits

MATERIALS: Basketball, coat hanger, tape, two or three feet of string, weight, pail, thimble

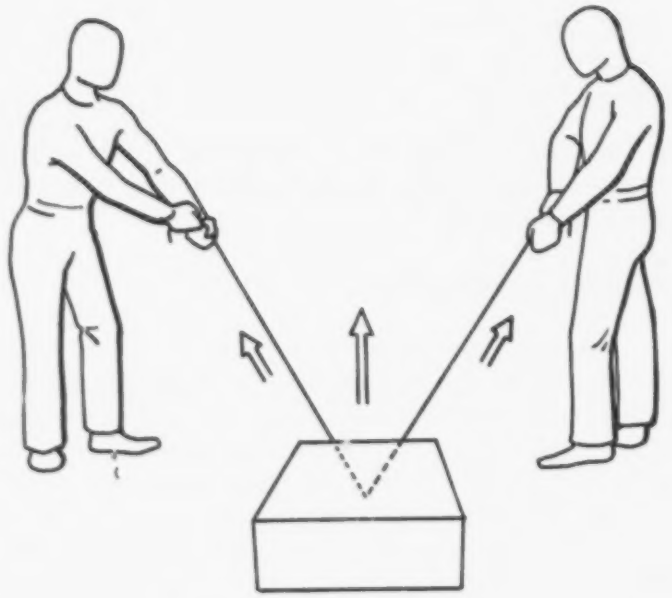


PROCEDURE: Place the ball in the pail; bend the coat hanger and tape it to the ball so that it is in an upright position; attach the string to the thimble and place it on top of the upright hanger. Attach the weight to the string. This device represents earth (ball) and satellite (weight). Push the weight away from the ball and observe how and where it turns. Lightly push the weight away at different angles. Experiment with speed, pushing it after it is in motion, etc. Determine what elliptical and circular orbits are. Discuss perigee and apogee.

EXPLANATION: The type of orbit is determined by the angle of insertion.

2. PROBLEM: Spacecraft Flight Path

MATERIALS: Weighted box, three five-foot cords.



PROCEDURE: Tie convenient lengths of cord to a common point near the front of the box. Have one student pull on one end in any direction and the second student pull at 90° angle to the first. Notice which way the box moves. Identify one force as gravity, the other as the inertia of the spacecraft and its velocity in a particular direction. Have one student pull faster, one with more force; change the angle of pulling and observe the movement of the box. Discuss with students how each situation can be applied to a spacecraft sent into space.

EXPLANATION: Many forces affect the flight of a spacecraft. The amount of forces and the direction of the forces have to be considered.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NASA SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: $.25.

TOPIC 5.03 **(7-9)**

A satellite passes over different parts of the earth on each revolution because the Earth is rotating beneath it.

LEARNING ACTIVITIES

1. Mark a globe with hour lines running from the North to the South Poles. Now rotate the globe and orbit a cut-paper satellite at the same time. If the satellite is one hundred miles from the earth and traveling at five miles per second, it would take approximately 87 minutes for a complete revolution around the Earth. Mark on the globe with chalk the spot directly under the satellite. Have the satellite make another orbit. Note the part of the earth which the satellite is over now. Make another chalk mark. Note the number of trips the satellite has to make before it passes over the same spot again. Flight paths of spacecraft are reported in newspapers. Perhaps the students would like to bring some in for class discussion. They will also point out that during our manned flights, Mission Control in Houston, Texas, and at Cape Kennedy use a large electronic panel showing the world. A light blinks to pinpoint the location of the spacecraft.

Mission Control Headquarters

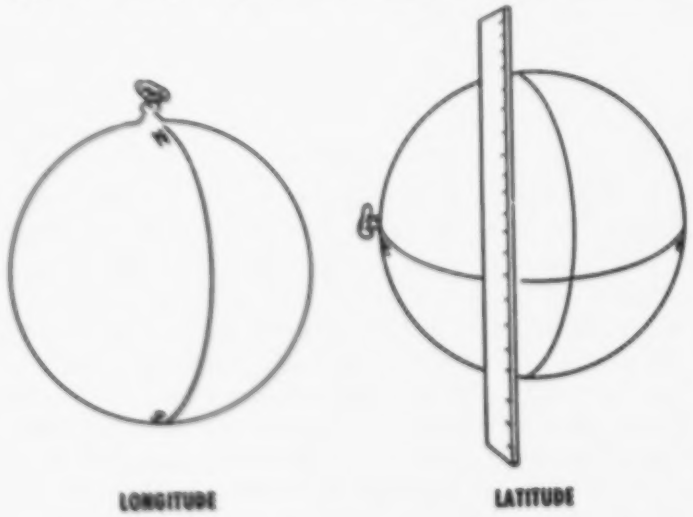
REINFORCEMENT

1. In addition to the foregoing "Learning Activity", or as a follow-up, some students may want to try the following for a better understanding:

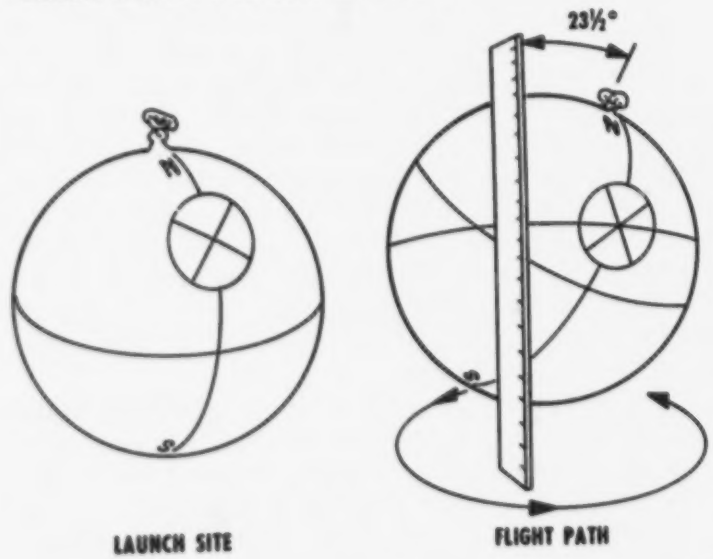
MATERIALS: Yardstick, large balloon (light green or yellow in color, able to inflate to at least 15" in diameter or larger, and circular in shape), two rubber bands, two felt markers (one black and one red), and one large map of the world (wall type).

PROCEDURE

1. Inflate the balloon. Bend over nozzle and tie off with a rubber band.
2. With a black felt marker, mark the North Pole (N) at the nozzle end and the South Pole (S) directly opposite and in proper position.



3. Lay the yardstick on the table and line up "N" and "S" Poles. Your partner will then support the balloon while you draw a straight line of longitude from "N" to "S" Pole with a black felt marker.
4. Turn the line of longitude perpendicular to the yardstick. Now you support the balloon while your partner draws a line of latitude around the exact center of the balloon with a black felt marker. Which line of latitude does this represent?
5. Refer to the world map and locate 80° "W" longitude and 29° "N" latitude. Where is this geographically? Mark an "X" on the line of longitude to represent point of rocket launching. Mark with a red felt marker.



6. What is the tilt of the earth's axis?
7. Approximate this tilt using the yardstick as a guide.
8. One person now holds the red felt marker on the red "X" while the other person rotates the balloon to form a complete circle keeping the proper degree of inclination by using the yardstick below, and his line of sight.

RELATED QUESTIONS:

A. What does the balloon represent?
B. What does the line of latitude represent?
C. What is the name of the point of rocket launch (geographically)?

D. How many times does the orbital path cross the line of latitude?
E. What would be the land mass crossed south of the line of latitude? Roughly make a sketch of that land mass on the balloon.
F. What other land masses would be crossed by the orbital path? Sketch those land masses.
G. Where would be good locations for tracking stations? Place dots to represent them on the balloon. What things must be considered?
H. Where should we try orbital maneuvers? Why?
I. What other experiences would you expect from your students during and after this exercise?

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Film:
"The World Beyond Zero;" 1964; NASA HQa-121, sound, color, 29 1/2 min., grades 9-adult.

TOPIC 5.04

(7-9)

Space vehicles are controlled by means of small rockets or thrusters. When fired, they nudge the vehicle in the desired direction. (These can be operated from the ground or if an astronaut is aboard, he may fire the attitude control jets, also called vernier rocket engines.)

LEARNING ACTIVITIES

1. See activities under Topic 4.15, with special attention to Newton's Third Law.
2. PROBLEM: Control of the rocket or satellite path

MATERIALS: Balsa wood block to be made into nozzle for balloon, balloon, wire.

PROCEDURE: Pupils will carve several simple wooden escape nozzles. The balloon will first be filled with air and released in the room. Note the erratic course followed by the balloon. The nozzles are now attached to several balloons. The balloons are launched as in rocket and jet experiments. The pupils will discover that the shape of the nozzle and the size of it will control the amount of thrust as well as direct the escaping air.

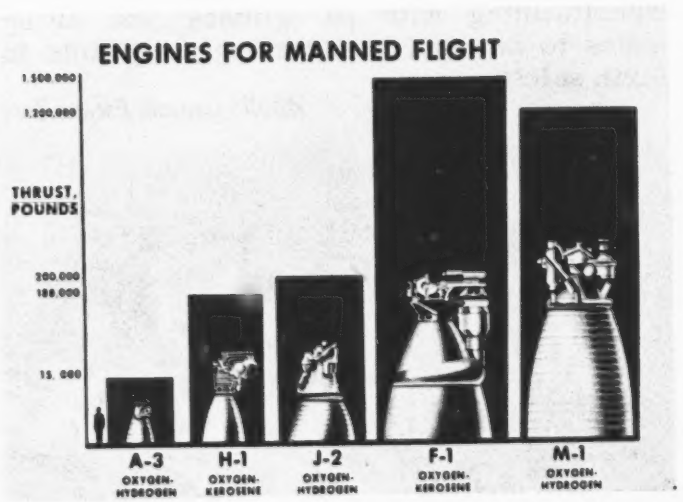
This activity may be done in more detail by attaching the balloon to a wire stretched across the room.

EXPLANATION: Carefully designed nozzles are very important for proper thrust, guidance, and control of launch vehicles and orbiting spacecraft.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NF-9 U.S. Launch Vehicles
NF-20 U.S. Launch Vehicles (Color supplement to NF-9)
NASA, SP-1; Short Glossary of Space Terms; 2nd Edition; Supt. of Doc.; Price: $.25.
Film:
"Before Saturn;" 1962; NASA sound, color, 14 1/2 min., grades 7-adult.



Two families of engines have been selected to support manned space flight. Size of each engine is indicated by comparison with the figure of the man. Both the H-1 and F-1 engines, shown in the illustration, burn liquid oxygen and kerosene. The J-2, burns a high-energy combination of liquid hydrogen and liquid oxygen, and is used for upper stages. Liquid hydrogen, a cryogenic (extremely cold) fuel with a boiling point of - 423° F., burns with liquid oxygen to provide a specific impulse about 40% higher than the conventional propellants used by the liquid oxygen-kerosene engines.

"Specific impulse" is the measure of thrust from each pound of propellant in 1 second of engine operation. It reflects the efficiency with which the rocket propellants are being used to generate thrust. Given greater specific impulses, rockets can launch heavier payloads, send them farther.

TOPIC 5.05

(7-9)

The spacecraft orbiting the Earth is returned to Earth by means of braking rockets or retro-rockets which are fired in a forward direction and thus slow the craft down counteracting the inertial movement away from the Earth. The Apollo spacecraft does not use retro-rockets. Parachutes are used at the proper time to slow the descent. Scientists are also experimenting with paragliders and lifting bodies to be used in returning astronauts to Earth safely.

Apollo Capsule Escape Test

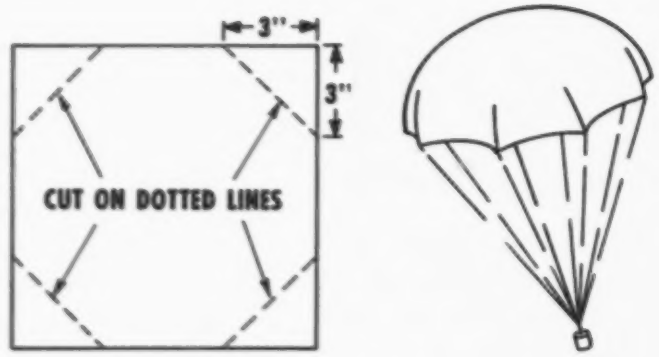
LEARNING ACTIVITIES

1. See Topic 4.15, with special attention to Newton's Third Law for Retro-Rocket Activities.

2. PROBLEM: Parachutes are used in the recovery of manned spacecraft and to slow jets landing at high speeds. The parachute system used is dependent upon the weight of the vehicle.

MATERIALS: Set of gram weights up to one gram, four pieces of cloth one foot square, ball of string, scissors, ruler.

PROCEDURE: Make an octagon out of the one foot square piece of cloth. This can be



done by cutting four triangles off the corners, 3" x 3". Tie a 12" piece of string to each of the eight corners. Tape the ends of the eight strings together so you can hook the weight to them. Hook first a one-quarter gram weight to the parachute and fold it neatly and take it outside and throw it up in the air. Note the rate of descent. Repeat these procedures twice using a one-half gram and a one gram weight.

RELATED QUESTIONS

A. As the weight of the vehicle increases, how must the chute system change?
B. What is one bad feature of a parachute recovery?
C. Can the size of the chute be increased forever? Why?

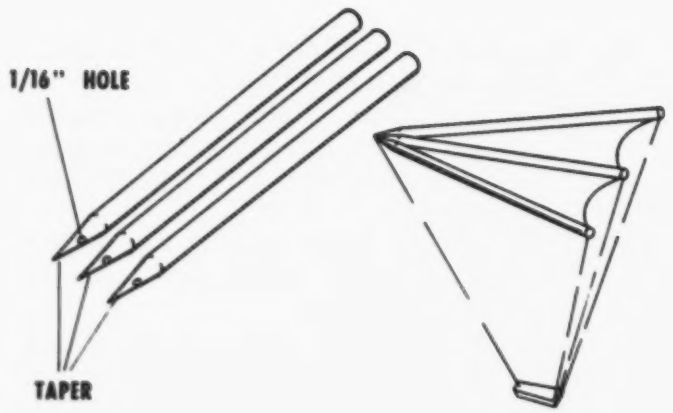
REINFORCEMENT

1. Information on projects involving paragliders and lifting bodies may be better understood by drawing comparisons with the familiar paper dart or with aspects of kite flying.

2. PROBLEM: Paraglider.

MATERIALS: Three 1/4" dowels 12" long, heavy tissue paper or wrapping paper, tape, scissors, knife, electric drill with a 1/8" or 1/16" bit.

PROCEDURE: Using the drill, make a small hole in one end of each dowel, about 1/2" from the end. Using the knife, taper the ends with the holes in them. Tie the



three ends together so they form a fan shape. Cut pieces of the paper to fasten over the dowels, making sure you allow some slack so the glider has two billowing sections. Tie a string to the end of each dowel and one to the front section so a weight can be tied to the strings.

EXPLANATION: NASA is experimenting with a paraglider which would be maneuverable and create lift. This device could be used to land space vehicles at a pre-determined area on land.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA Fourteenth Semi-Annual Report to Congress, July 1 - December 31, 1965; Supt. of Doc.; Price: $1.25

Film:

"Returning From The Moon;" 1966; NASA HQK-SR9; sound, black and white, 28:21 min., grades 7-9.

Paraglider

HL-10 Lifting Body

TOPIC 5.06

(7-9)

Long range rockets have guidance systems which work on the principle of comparing present position with point of destination. In travelling to the moon the astronauts have to navigate by using the earth and the moon as frames of reference. Tracking stations can also locate a satellite exactly.

LEARNING ACTIVITIES

1. The following demonstration should help to orientate the pupils to the problems of space navigation:

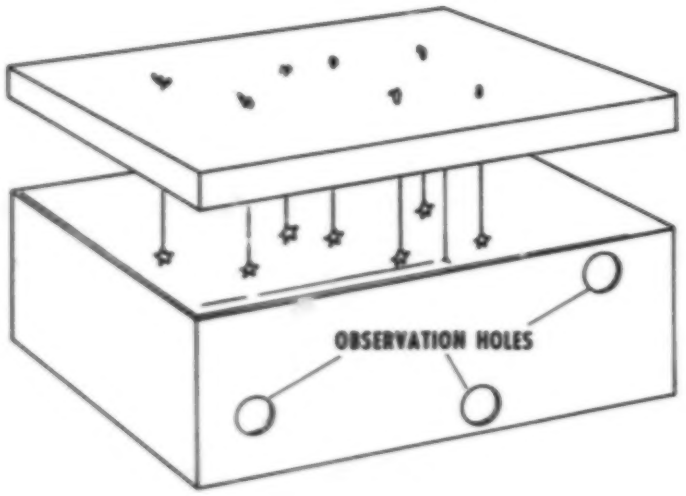
Have the pupils observe a child drop a ball to the floor. What is the path of the ball as it drops? (straight down) Now ask the pupils to imagine that they are standing beside a road. A truck goes by which has glass sides so that they can see inside. In the truck they observe a child drop the same ball. What is the path of the ball from the frame of reference of the pupils standing beside the road? (a curve called a parabola) What is the path of the ball from the frame of reference of the pupil in the truck? (a straight line).

2. Have the pupils experiment with frames of reference such as: throwing the ball to someone who is running, plotting the paths of a child on a ferris wheel as seen by: friends on the ground, friends on the wheel, himself, etc.

3. PROBLEM: Problems in space navigation

MATERIALS: Thread or string, stars cut from paper, tape or tacks, shoe box

PROCEDURE: Suspend thread from the top of the box. Hang the paper stars on the thread. Hang them in such a way as to take on the shape of the Big Dipper and place the cover on the box. Make several holes in the



sides of the box for the pupils to look through. Have the students look through the holes from a given point. Now have them move. Dipper will probably no longer have its familiar shape. Explain and discuss the fact that when we travel in space the appearance of the constellations will be different. This will affect an astronaut's bearing on direction when flights to the planets become a reality.

EXPLANATION: The appearance of the constellations in space depends upon the position that they are viewed from.

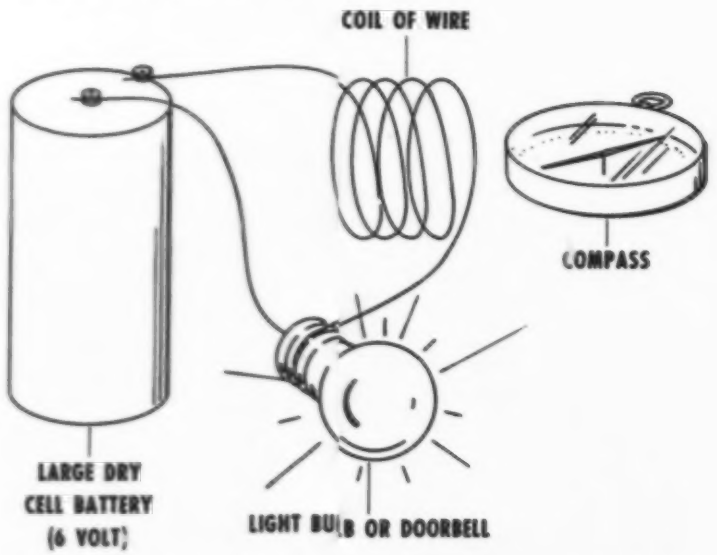
REINFORCEMENT

1. PROBLEM: Illustration of how the earth's magnetic field is used to orient a Tiros satellite in space.

MATERIALS: Bar magnet, dry cell battery, paper, light or bell, iron filings, compass, copper wire.

PROCEDURE: Place a magnet under a piece of paper and sprinkle iron filings evenly over the paper. Gently tap the paper until the filings form a pattern over the magnet. (The pattern is caused by the filings falling into place along the lines of force between the North and South poles of the magnet. Although this is a two-dimensional picture, it resembles the earth's three-dimensional field.) Hold a small compass over the pattern and observe where the needle points in relation to the lines of force. If we could put a magnet in a small satellite near the earth, we could point it in outer space.

Now set up the following apparatus: Attach a large dry cell battery (six-volt) by a coiled copper wire to a light bulb or doorbell. Move a compass up to and through the coil to see where the needle points.



EXPLANATION: With a current loop around the base of a Tiros satellite, it is possible to point or orient it in outer space.

2. PROBLEM: Illustration of how tracking stations can locate a satellite exactly.

MATERIALS: Transistor radio

PROCEDURE: Turn on the transistor radio and tune it in on a station. Turn the radio around and listen to the strength of the signal received. Change the direction of the radio. Discuss the relationship between the location of the radio station and direction of the transistor radio.

TRACKING provides the information continuously reporting the location of a satellite; a probe that is going deep into interplanetary space, or of small rockets that will penetrate space on an up-down path, perhaps only a few hundred miles. Location is important for the scientist-experimenter because he has to know precisely where the spacecraft is at a particular point in time so he can correlate an event measured by the spacecraft with, for example, its position relative to the sun, the moon, or earth. He has to know its position to send it guidance information, to send it commands to make observations, transmit data or change flight plan.

EXPLANATION: A radio transmitter on a satellite can be used to aid in locating and tracking a satellite.

3. One of the most essential safety systems for our astronauts is the global system of tracking stations and communications networks. Children will appreciate their significance more if they locate them on a map of the world. Following are a few approximate locations:

1.	27° N; 128° W; RXV	Ship at sea
2.	28° N; 110 1/2° W; GYM	Guaymas, Mexico
3.	28 1/2° N; 80° W; CNV	Cape Kennedy
4.	12° N; 9 1/2° E; KNO	Kano, Nigeria
5.	21 1/2° N; 159° W; HAW	Hawaii
6.	26° N; 145° W; RTK	Ship at Sea

4. Invite a "ham" operator to class to tell about monitoring satellites.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

"The Four Days of Gemini Four;" 1965; NASA HQa-134; sound, color, 28 min. All Grades.

"Computer For Apollo;" 1966; NASA HQK-SR6, sound, black and white, 29:53 min., grades 7-adult.

TOPIC 5.07

(7-9)

Selenology is the branch of astronomy that is concerned with studies of the Moon. The following information and activities will lead the student to a better understanding of present theories about the Moon.

LEARNING ACTIVITIES

1. "Lunar Origin".

CONCEPT: To investigate the basis of the theory of the Moon originally coming from the Earth.

MATERIALS: Globe.

PROCEDURE: Some scientists feel that the Moon was once a part of the Earth, billions of years ago when the Earth was in a molten state. They theorize that the blob pulled off that eventually became the Moon. Take a globe and investigate the following:

a. What is the general shape of the Pacific Ocean?

b. What type of terrain surrounds the Pacific?

c. Examine the other half of the globe. Do the continents seem to be huge, jig-saw puzzle pieces that would fit together?

If the Moon was formed from the Earth's crust, its composition will be roughly constant throughout. If, on the other hand, the Moon and Earth were formed from adjacent but separate gas clouds, the interior of the Moon will be similar to that of the Earth, just proportionally smaller. The Earth is known to consist of several distinct regions or zones, each characterized by its own properties of location, hardness, composition, etc.

The interior can be studied with seismometers, an instrument that records sound waves generated by quakes and tremors. The different regions of the Earth will transmit and reflect sound waves in separate, distinct characteristic ways. These waves can be generated by artificial means with high explosive charges.

EXPLANATION: This theory holds that the Moon was once a blob that was pulled off the Earth by centrifugal force, leaving the Pacific as a scar. There are some drawbacks to this theory. The most significant is the fact that at present it is impossible to account for a rotational speed necessary to throw the Moon up, away from the Earth. Further studies of the Earth's Magnetic field, by near-orbiting scientific satellites, may show that this also played a role significant enough to provide the additional force required.

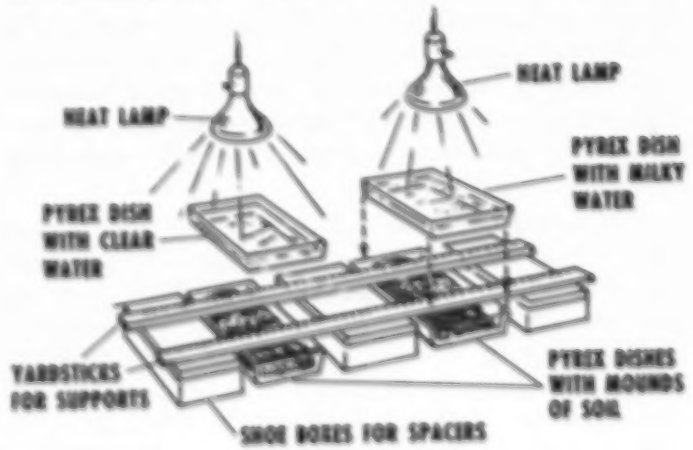
2. Atmosphere

CONCEPT: Surface temperatures of the Moon undergo extreme variations due to the lack of a dense atmosphere.

MATERIALS Two infra-red heat lamps with clamp-type holders
Four clear glass, pyrex-type, baking dishes (square)
Two Fahrenheit scale thermometers (lab type)
1/2 pail of sand or dirt
1/2 pint milk or white ink
Two ring stands
Three shoe boxes
Two yard sticks

PROCEDURE Assemble apparatus as shown in diagram. Form mound of dirt in bottom dishes. Fill one of upper dishes 1/2 full of clear water and fill other dish 1/2 full of milky water. Insert thermometers so that bulb tips are approximately 3/4" below surface of dirt. Turn on both heat lamps. Re-

cord temperatures reading of both thermometers every 15 seconds for approximately 5 minutes of until temperatures stabilize.



RELATED QUESTIONS:

a. What do the following items represent:
   Heat lamp — Milky water
   Clear water — Soil dishes
b. How could you vary the density of the atmosphere in this demonstration?
c. What effect does the height of the dishes containing the liquids have on the soil temperature? What could this represent?
d. How can this apparatus be used to demonstrate night temperatures on the lunar surface?
e. What is the relationship between extreme temperature variations and weathering? How does this affect the lunar surface?
f. Outline simplifications and variations on this technique.

3. "Weight on the Moon and the Planets"

CONCEPT: Size of object (planet, moon, etc.) affects weights of objects.

MATERIALS: Pails (same size)
7 lbs. sand
2 shopping bags

PROCEDURE: Fill one pail with 6 pounds of sand. (surround with bag). Fill another pail with 1 pound of sand (surround with bag). Have students feel the difference in weight. The 6 lb. pail represents 6 lbs. on the earth. The 1 lb. pail represents 6 lbs. on the Moon. Fill other pails with other planet proportions: e.g., Jupiter's gravity is 2.6 that of the earth's; therefore, the Jupiter pail would contain 15.6 pounds of sand.

RELATED QUESTIONS:

a. How will differences in gravity affect man's ability to do work on the surface of the Moon?
b. How will this affect the design of Moon roving vehicles?
c. What statements can you make regarding rocket lift-off from the Moon as compared to Earth's lift-off (thrust)?
d. Will construction design and materials be different depending upon which solar body is being explored? Explain?
e. What is mass? What is weight? Does a weightless object have mass?

4. Reflective qualities of a body in space indicate the nature of its surface texture.

MATERIALS: Sources of light (gooseneck lamp) Different colored paper. Different grades of sandpaper fine to coarse.
Footcandle meter, or light meter.

PROCEDURE: Shine light at an angle on paper. Use sand paper and notice the amount of illumination that the light meter records. Experiment with different colors and establish a scale of reflected light. Tear papers and place combinations on another paper.

RELATED QUESTIONS:

a. Using your results as a guide, discuss the nature of the Moon's surface and the amount of light it might reflect.
b. Would observation in a. above be the same for the earth.
c. Why do some areas on the Moon appear darker than others?
d. What types of problems, due to light reflection, might our astronauts experience while on the Moon? How can these be corrected?

REINFORCEMENT

Geology is the science which treats of the history of the earth, especially as recorded in the rocks. When we make reference to Lunar Geology we mean an extension of the science and its principles to the lunar terrain. A man studying the earth is called a geologist. A man studying the moon in general is called a selenologist. We want to apply science in order to discover and understand the history of the moon. For centuries man has looked and wondered at the moon. Parmenides in the 5th Century B.C. suggested that the moon's light was simply sunlight reflected from its surface. Anaxagoras about the same time believed that the moon was solid. He said the darker areas on its face were the shadows of tall mountains and deep valleys. Others believed that the moon was simply a reflection of the light of a central fire which was concealed by the earth's bulk and thus invisible to the people of the known world. Others said that the moon was a reflection from the sun which in turn represented a reflected light itself.

Many ancient peoples worshiped the moon as a goddess. Her added light enable the hunter and the farmers in the fall to gather additional food during the harvest season - thus the name Harvest Moon in September and Hunter's Moon in October.

By watching the changing phases of the moon the name "moonth" was given to the time interval between one new moon and the next.

The first day of the week was set aside to worship the (Sun - God,) thus it was called the Sun's Day. The second day of the week was for worshiping the Moon or the Moon's Day; thus the origin of Sunday and Monday. These Greek mythologies are very interesting and enlightening if only because they help us realize how far we have come since the 5th Century B.C. We all hear so much today about going to tne Moon. It has been called lunar lunacy by some and, as you know, mentally disturbed people were at one time believed to be influenced by changes of the Moon. The people working on the Moon project are in fact influenced by changes in our understanding of the Moon by scientific advancement, but not in the superstitious way of many years ago.

Most of us, when we see something exciting and interesting, want to investigate it and become involved in it. This is human nature. For years men have wanted to visit the Moon. They have wanted to study it first-hand: hold samples of the lunar terrain in their hands; walk on its surface under 1/6th of the gravitation's force of the Earth. We have wanted to measure its atmosphere, take samples of it, study its magnetic field, photograph it, study the erosion. In general, we have wanted to study it as we have our own Earth and to apply the science of geology to it, as well as physics, chemistry, etc. Man will visit the Moon and apply the sciences we have developed here on Earth to the lunar terrain.

The question about the origin of the Moon is very interesting. There are many theories that have been proposed. Activity #1 is concerned with one of the theories and the students can investigate additional theories.

Perhaps the secrets of the origin of the solar system are locked up in the Moon. Man, by applying science there as he has here on the Earth, will learn more about our early beginnings.

As an astronaut, you want to know all you can about the Moon before you get there. We want to know about the atmosphere, light reflection, gravity, the type of terrain we will be walking on, and taking samples of.

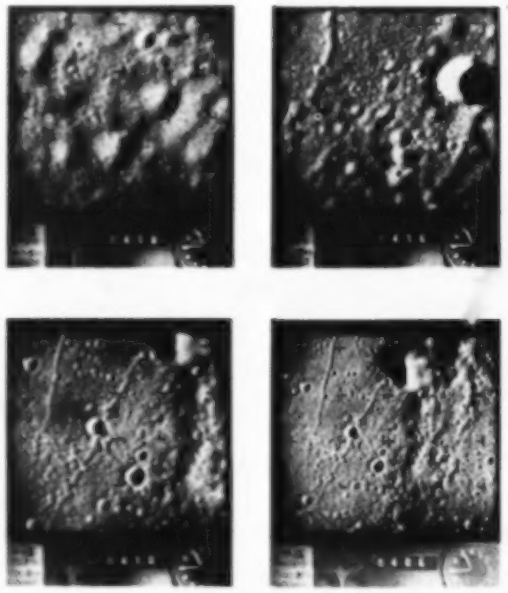
Some measurements can be made by observations from the Earth.

1. Atmosphere: 10^{-5} that of the Earth. Consists of H_2O and CO_2 and H_2 with maybe some SO_2, Krypton and Xenon.

   The lunar atmosphere pressure equivalent to Earth's at two hundred miles altitude. Scientists generally agree that the Moon had a denser atmosphere at some stage in its evolution.
2. Gravity: one-sixth that of the Earth's calculated.

3. Temperature measured from Earth and confirmed by Surveyor. We have observed other things about the Moon through telescopes, i.e., the craters, maria, rays, rills.

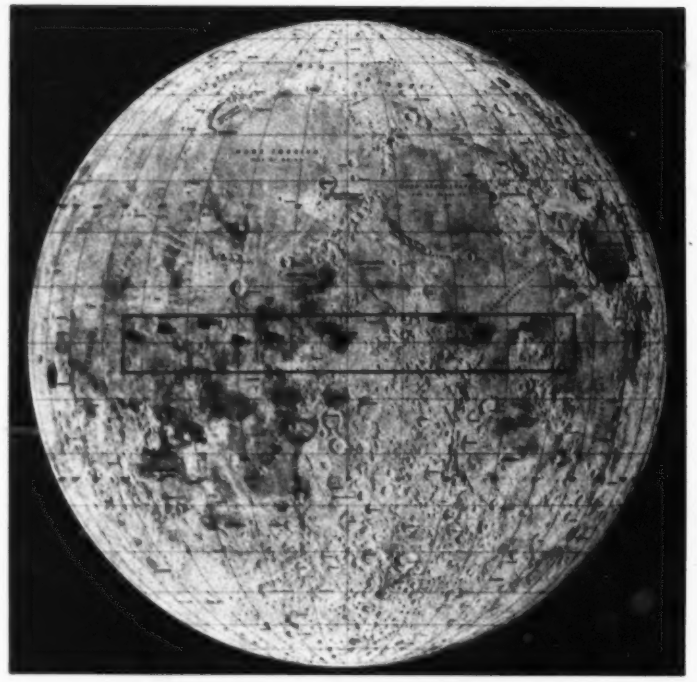
Ranger IX Photos of Moon



Ranger IX views of Alphonsus, from 50.3 miles, 35 miles, 12.2 miles, and 4.5 miles; sunlight from left, North at top, impact area marked by white circle.

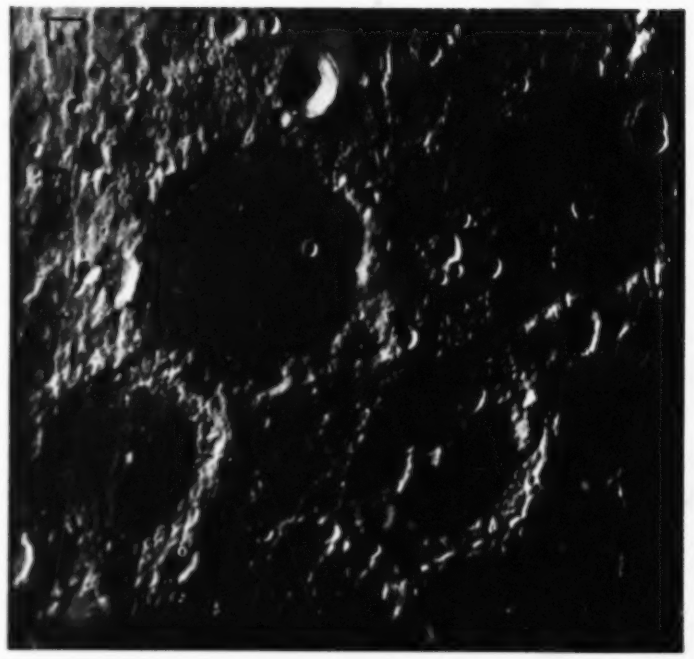
The Ranger series of spacecraft gave us photographs one thousand times better than any ever taken from the surface of the Earth.

Lunar Orbiter Photo Site



Study planned photographic sites for Lunar Orbiters.

Ranger IX Photo Just Before Impact



Discuss visible feature in these Ranger IX photographs; point out types of craters, i.e.:

a. Primary
b. Secondary
c. Ghost
d. Overlapping
e. Age--older

Question: How were the craters formed?

a. Impact theory--. Have the students find out what tektites are.
b. Volcanic theory--helps explain the maria as being lava flows.
c. Combinations of the two theories.

The Surveyor spacecraft gave us more information. The first Surveyor flight was a tremendous success. Have the students make a list of what we want to measure on the Moon and discuss how the Surveyor spacecraft can make those measurements. For example:

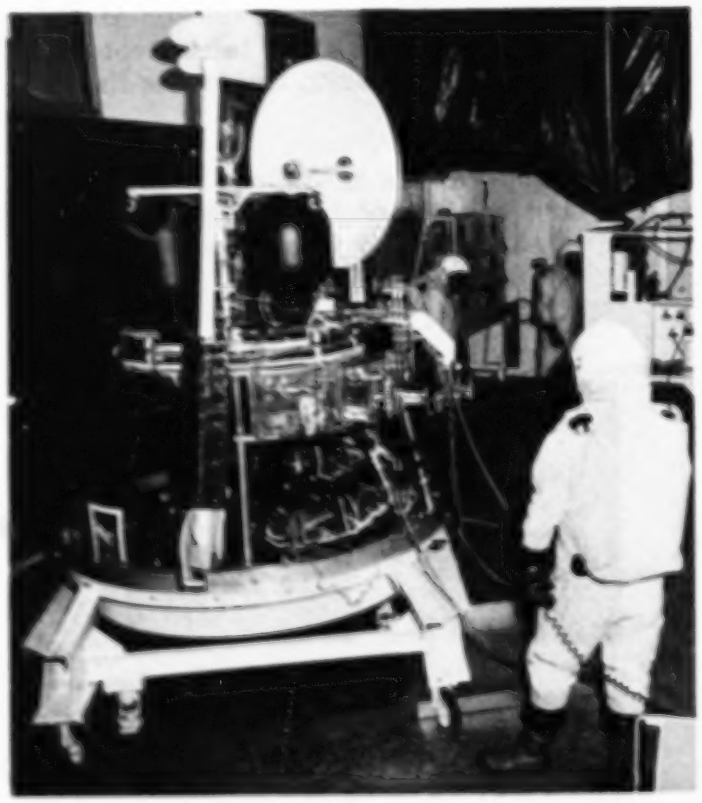
a. Surface hardness
b. Physical and chemical properties of the luraine.
c. Seismic activity of the Moon.
d. Micrometeorite environment near the surface of the Moon.
e. Can the TV camera give us information on the general characteristic texture of the lunar surface? See "Learning Activity #4". Look at photos taken by Surveyor I, and collect more recent Surveyor photos.
f. Surface bearing strength is important to know. Why?
g. Compare temperatures on the lunar surface taken by observation made from the earth and measurements made by the Surveyor spacecraft.

All of this information is for the Apollo program and the day when man sets foot on the Moon.

BEFORE ENHANCEMENT AFTER ENHANCEMENT

SURVEYOR MISSION A
SPACECRAFT FOOTPAD

Lunar Orbiter Fueling Simulation



While we were gathering this information, another series--Lunar Orbiters--were taking photographs of the surface of the Moon which enables us to select the best landing areas on the Moon. Best for:

a. Astronaut safety
b. Communications
c. Scientific information and explorations.

Discuss Lunar Orbiter photos and the sun angle--shadows on the surface--types of craters - age of craters, etc.

Notes for photo discussions:

a. Sharp crater edge indicates "younger" crater than one with rounded edges. "Young" craters overlap older ones. Partially buried craters, known as "ghost" craters, are older. Brighter rays come from younger features which cause them; one theory is that radiation will cause darkening of most material with time.

b. Central peaks which occur in craters are believed to be due to rebound or are volcanic in nature.

c. Optical properties of ray materials indicate they are composed of volcanic glass, e.g., Similar to Obsidian.

d. Maria, some theorize, are lava flows 1.9×10^{-9} years old. Maria may have been formed long after the Moon was formed and all at about the same time. Chain craters formed after maria. May be of volcanic origin. Craters occur only 1/10th as often in maria as in highlands. These are about 20 maria over about one-half of the Moon's surface--largest is the Mare Imbrium (Sea of Showers) and it is 750 miles across.

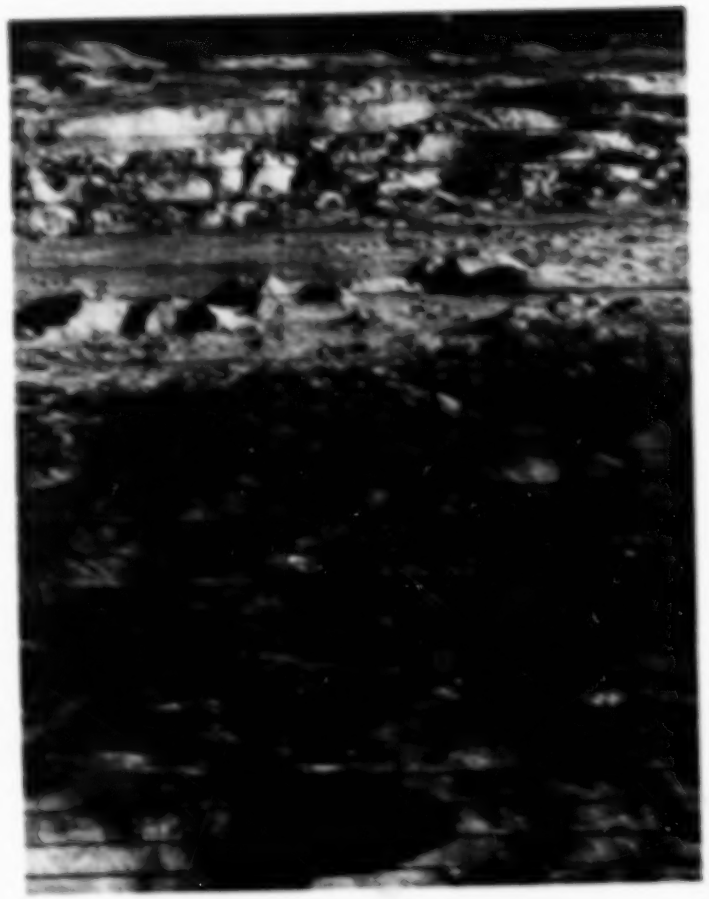
e. Number of craters increase as size decreases.

f. Little folding of the Moon's surface is a discernible difference between Earth and Moon.

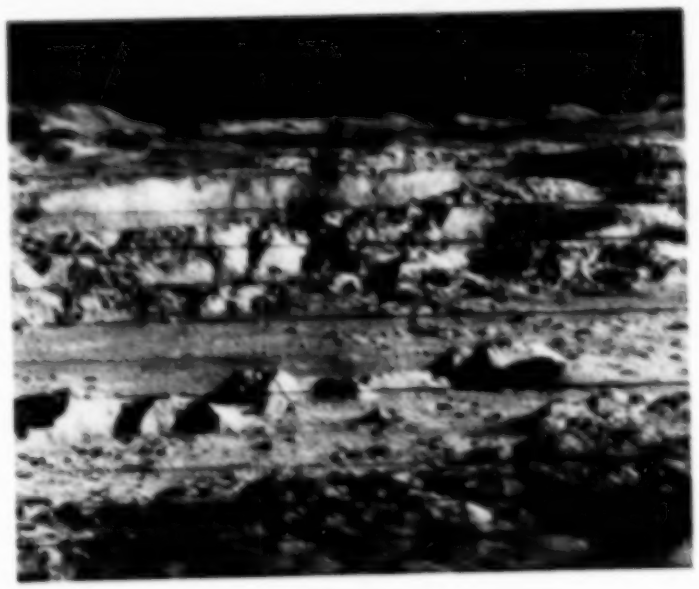
g. At -150°C and 0° pressure water has vapor pressure so low that it would remain supercooled for millions of years. Bottoms of craters and shadowed portions of deep craters are able to meet these requirements.

h. Moon's density is only 60 per cent that of the Earth's. Thus, according to the Dumbell theory, it would be granite or stony and not metallic.

Copernicus Crater



Copernicus Crater



i. We can measure the lengths of shadows to determine heights of mountains.

j. Copernicus may actually be a series of interconnected ridges surrounding a plain (40 mile diameter) surrounded by walls, the peaks of which are 56 miles apart.

k. Largest crater is 145 miles in diameter--Clavius.

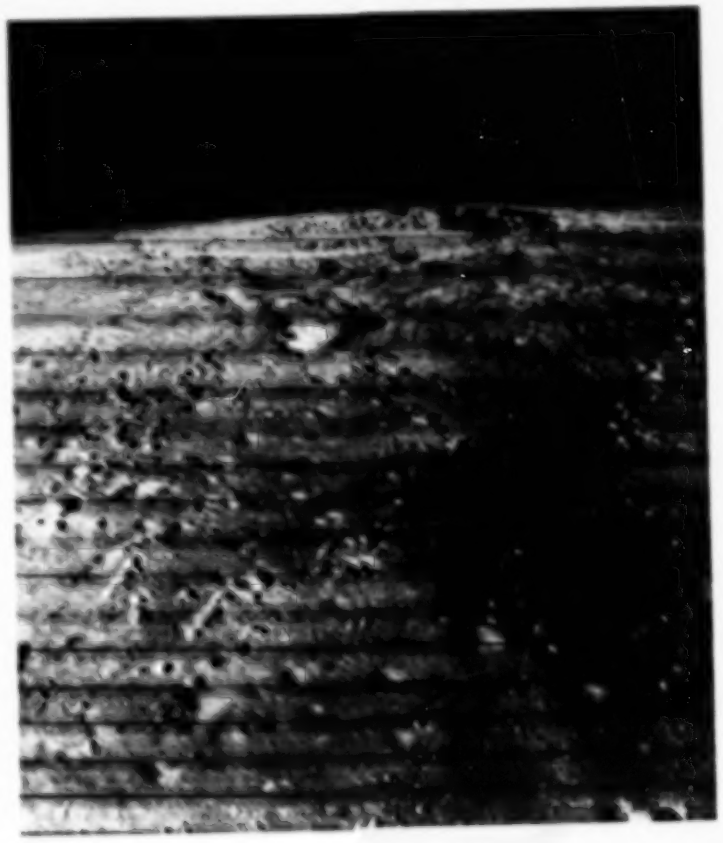
l. Tycho is in the southern sector.

m. Rays' origin a great mystery. Some theories on their cause are:

a. Cracking of crust
b. Saline deposits
c. Splash of meteorite impacts.

There has been no single explanation that fits all observations.

Copernicus Crater



Surveyor has proven that the bearing strength of the Moon is sufficient to support the Lunar Module and the two astronauts.

NASA is studying roving vehicles which may be placed on the Moon to enable the astronauts to explore greater areas of the surface of the Moon. Walking and working on the Moon will be tiring; therefore, a mobile vehicle will be necessary for extensive exploration of the lunar surface.

SUMMARY

We have reviewed what we know about the Moon through observation from the Earth and by using photos from our spacecraft.

We have discussed some of the things we can tell by looking at photos of the Moon, and the experiments we want the Surveyor series to perform before we send a man to the Moon.

Much of the success of man's trip, as well as future missions to the Moon, depends on the success of the missions leading to the first manned Apollo mission to the Moon. Then, it is the man applying his ability and skills to observe, evaluate, and conquer the unknown. Man is, after all, the only system that can discover the unknown. We cannot build mechanical systems that can do this.

How far have we really come since the 5th century B.C., and how far will we be by the 50th century A.D.?

LUNAR PROBES:

The Moon, Venus and Mars were selected as the most logical bodies for exploration. The first phase was the Ranger program.

RANGER SERIES:

OBJECTIVE: To obtain close-up pictures of the lunar surface. Information about relative smoothness and bearing strength of the lunar surface. Information to support Surveyor and Apollo programs.

Spacecraft: "Bus" is five feet in diameter, 8 1/2 feet long; panels out - 15 feet and 10 1/4 feet high. 807 pounds.

High Gain Antenna: Narrow beam signal with maximum strength in a given direction toward the Earth.

Omni-Antenna: Receives signals from all directions.

Solar Panels: 24.4 square feet of solar cell area - 200 watts of power. Nearly 10 thousand solar cells.

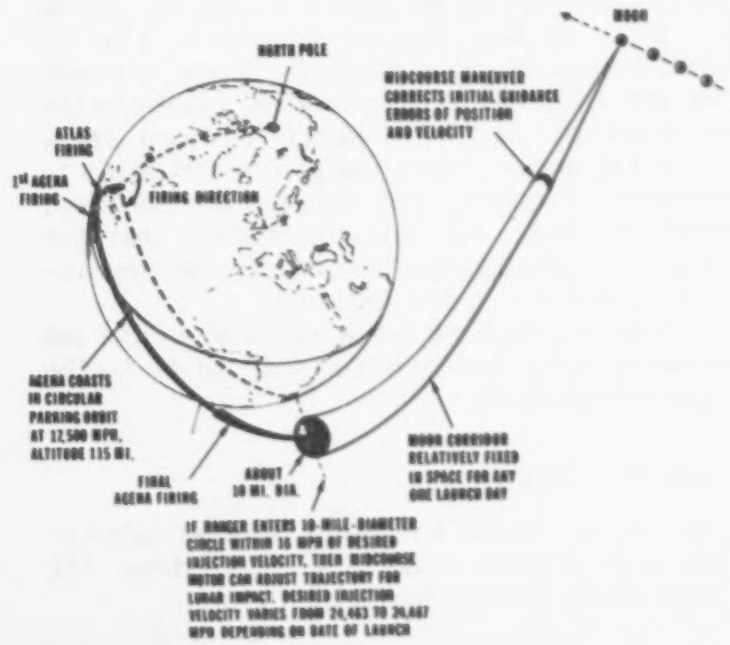
Batteries: Silver and Zinc (Ag-Zn) = 84 ampere.

Camera System: Full and partial scan (F & P) cameras - 6 total.

Atlas-Agena Launch: Only time was during third quarter phase. 90 to 150 minutes on six days every 28 days - Moon is traveling at two thousand miles per hour.

Parking Orbit: Circular at about 115 mile altitude.

TYPICAL RANGER LAUNCH TO MOON



Moon Corridor: About 10 miles diameter. Must enter corridor within 16 miles per hour of desired injection velocity so that mid-course motor can adjust for lunar impact.

Roll and pitch velocity changes are necessary. Injection velocity range is 24,463 to 24,487 miles per hour depending on launch date.

Terminal Maneuver: One hour before impact it is necessary to line up cameras. The line up begins about 3,940 miles from the Moon.

Ranger VII gave us our first close-up photos of the luraine.

We had only about 20 minutes to take and transmit approximately six thousand photos back to Earth before 5,850 miles per hour impact.

The journey to Moon takes about 65 hours or about 2 3/4 days.

Ranger IX impacted in Crater Alphonsus within three miles of the aiming point.

Results:

a. New information about the luraine.
b. Topography and structure photographed.
c. Lunar surface smoother than predicted.
d. Not much evidence of volcanic activity.
e. No fissures nor boulders were photographed.
f. High resolution photos were obtained in four different areas of the luraine.
g. Surface features as small as 10 inches in diameter were photographed by Ranger IX.

Note:

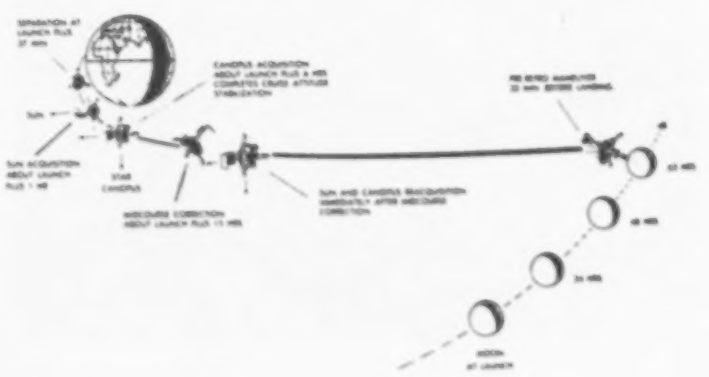
Gravitational pull of sun, Jupiter, Mars, and Venus also influence the flight of Ranger.

SURVEYOR SERIES:

Objectives:

1. Soft lunar landings.
2. Discover and verify landing sites for manned lunar missions.
3. First flights were to give us engineering data.
4. The follow-on flights carry scientific instruments to obtain additional data on surface characteristics.

SURVEYOR FLIGHT PROFILE



Mission Profile:

66 hour flight
6,000 MPH approach
Must slow to about 14 MPH to survive landing.
Launch weight - 2,250 pounds
Large "solid" retro-rocket and three small throttleable (vernier) engines reduce descent speed to about five feet per second.
Spacecraft falls the last 13 feet to the surface.
Impact absorbed by tripod landing gear and crushable pads.
TV photos are transmitted to Earth.
360° swivel - above and below horizon; portion of view will be stereo.

Spacecraft:

85,000 component parts on each engineering spacecraft.

12,000 additional on operational versions.

No parking orbit is used - launch pad to translunar trajectory.

Sun and Canopus are celestial reference points.

Scientific missions include:

a. Measure surface hardness - bearing strength.
b. Measure surface physical and chemical properties.
c. Seismic activity.
d. Micrometeorites near the surface.
e. TV camera - character and texture of luraine.

Launch Vehicle:

Atlas-Centaur

10 feet in diameter - 113 feet high.
Weight is 300,000 pounds fueled.
Thrust is 367,000 pounds.
Centaur - 30,000 pounds thrust and has a two burn capability.

LUNAR ORBITER SERIES:

Objective:

To continue efforts of Ranger and Surveyor to support Apollo and to enlarge scientific understanding of the Earth's nearest neighbor.

Basic task is to obtain photographs of various types of surface on the Moon to assess suitability for Apollo landing sites. Within 10° N, and 10°S, latitude and 60° E, and 60° W, longitude.

Study of meteoroids and radiation in the vicinity of the Moon as well as the Moon's gravitational field.

Orientation is obtained by acquisition of the Sun and Canopus by star trackers. Five hundred and fifty miles from Moon, the liquid retro-engine slows craft so that the Moon may capture it. Orbit is approximately 1,150 miles by 125 miles.

Later the perilune is adjusted to 28 miles by 1,150 miles (apolune).

From launch to complete readout of all photography requires about 35 days. At least 30 additional days are required for a preliminary analysis of the pictures.

Lunar Orbiter is a flying photographic laboratory. It weighs 850 pounds. At launch it is five feet in diameter and 5 1/2 feet tall. Panels and antenna deployed, it is 18 1/2 feet across the antenna and 12' 2" across the panels.

The photo lab has been compressed into an egg-shaped pressure shell weighing 150 pounds. It includes two cameras and a 200-foot roll of film. The film is shielded from the radiation from solar flares.

Image motion compensation is automatically made.

In the processing system, the film is chemically developed. The negative film is then dried by a small electric heater and stored on a reel until the electronic readout process is to begin.

The densely packed information on the film must be changed into a stream of electronic signals which can be transmitted to Earth. A film scanner and a photo-multiplier are the heart of the readout equipment. The electronic signal proportional to the intensity of the light is amplified, timing and synchronization pulses are added and the result is fed to the communications link for transmission to the Earth.

Readout is not begun until the final picture has been taken. Readout is in reverse order and may be repeated, if required.

Preliminary Results:

In some photos of the back side of the Moon there appears to be fracturing on the floor of one of the craters. These fractures may substantiate those who believe there is or has been volcanic activity on the Moon. We have also seen displacement of wall material in an older crater, suggesting that the newer crater was formed by a meteorite impact cascading surface material into the older depression.

SPACE STATIONS

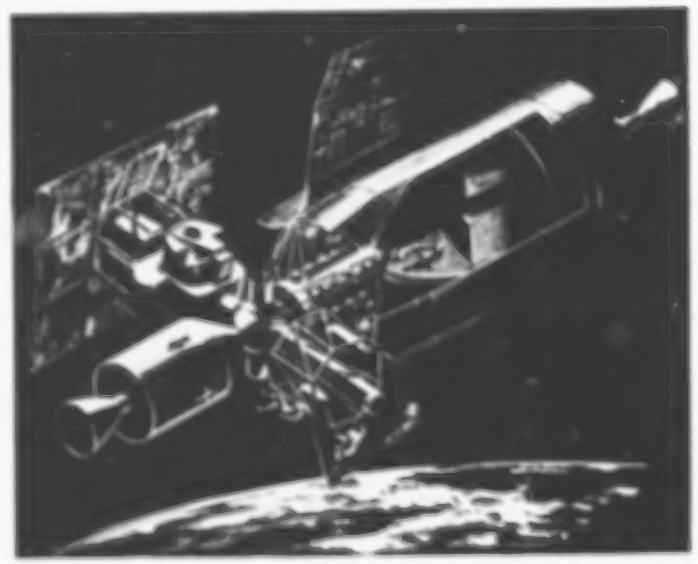
Studies are going on to see what is needed in order for us to fly a space station.

Concerns:

a. It may or may not be necessary to have artificial gravity. "Convenience level" gravity could be accomplished by spinning the station-by tieing another vehicle as was done in GT-11 and GT-12.

b. Costs - Present plans are to use Apollo Command and Service Modules with the S-IVB spent stage of a Saturn 5 as an orbital workshop as interim space station. Three men could stay in orbit up to 30 days and could be extended by resupply flights, but this is not a true space station. The big question seems to be "When, not "Will we".

Spacecraft Terminal



1. TOPIC: "Lunar Craters - Astronomical Theory".

CONCEPT: Many of the craters visible on the surface of the Moon may have been caused by the impact of meteoroids.

MATERIALS: Flour, grape nuts, sand (fine), photos of Moon's surface showing lunar craters, ball bearings (assorted sizes and shapes), marbles, water, and containers (shirt boxes or cake pans).

PROCEDURE:

a. Prepare containers with 1/2" to 1" of the following materials:
   - Container "A" - Flour
   - Container "B" - Fine sand
   - Container "C" - Water
   - Container "D" - Damp sand

b. Throw objects into above prepared containers, varying their speed and angle of impact.

c. Compare patterns formed in the containers with photos showing lunar craters.

Note: It is possible to make a permanent Moon surface model by using plaster of Paris in container.

RELATED QUESTIONS

a. Speculate as to the shape and size of objects which may have formed lunar craters.

b. How do the velocity and angle of impact affect the size and shape of the craters?

c. Determine how it is possible to tell the "age" of the lunar craters. Duplicate old and new craters in one of your containers.

d. Discuss possible reasons for the comparative absence of craters on the surface of the Earth.

2. TOPIC: "Lunar Craters - Volcanic Theory".

CONCEPT: Some scientists believe that many of the lunar craters are of volcanic origin.

MATERIALS: Photos of Moon's surface showing craters, container (thimble or bottle cap), one plastic funnel, ammonium bichromate crystals, dictionary, and asbestos.

PROCEDURE:

a. Fill the bottle cap or thimble with ammonium bichromate crystals and light with a match.

b. Observe results.

c. Do not inhale fumes.

RELATED QUESTIONS:

a. Make a general statement explaining the color of the ash material formed.

b. What observations can you make concerning the volume of the ash compared to the original amount of ammonium bichromate?

c. Locate craters on your moon photos showing similar characteristics to the one formed in your container.

d. Can you locate other characteristics in the moon photos typical of volcanic action?

3. TOPIC: "Moon Roving Vehicles"

CONCEPT: The nature of the moon's surface requires use of novel and unique "wheels"

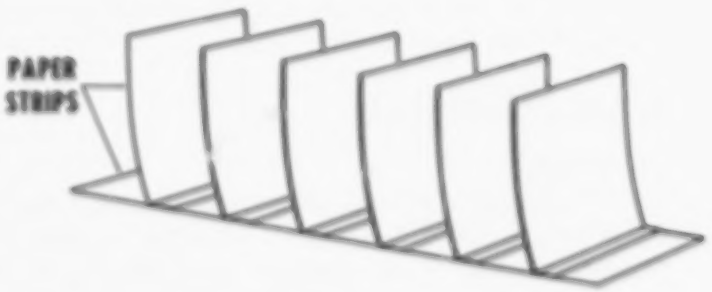
MATERIALS: Oak tag or Bristor board
Transparent tape
Scissors
Pencil
Stapler

PROCEDURE:

a. Cut 2 strips of oak tag 2" by 18".

b. Cut 6 strips of oak tag 2" by 3" from one of the 2" by 18" strips.

c. Staple 3" strip to 18" strip at 2" intervals.



d. Draw ends of long strip together to form the rim of the wheel.

e. Attach loose ends to the pencil.

f. This wheel is a model of the "metalastic" wheel concept developed by Grumman Aircraft Corporation. This configuration has been under exhaustive research.

RELATED QUESTIONS:

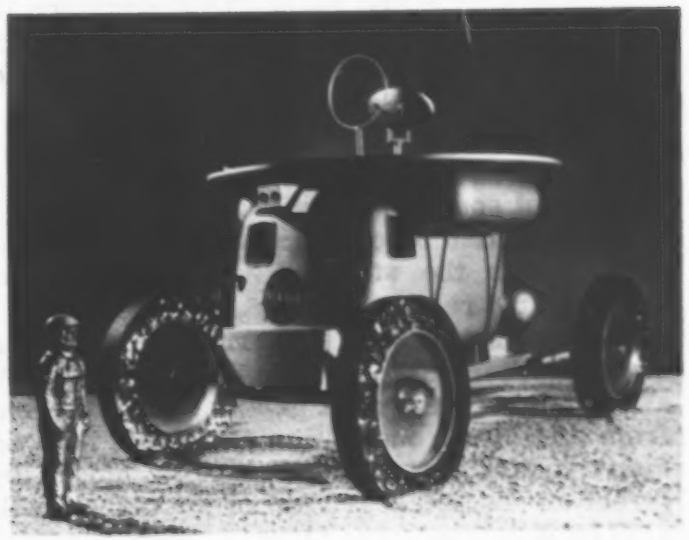
a. By rolling the wheel over objects of different heights and shapes, determine what advantages or disadvantages it has for lunar logistics.

b. Specualte as to what other shapes could be used other than conventional wheels.

c. Make a list of characteristics necessary for any type of device which would transport astronauts on the lunar surface.

d. Can you invent a different type of moveable device to explore surface of the moon?

Mobile Lunar Laboratory



REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Newell, Homer E.; SURVEYOR: CANDID CAMERA ON THE MOON; National Geographic; October 1966.

Films:

"The First Soft Step;" 1966; NASA HQK-SR1; sound, black and white, 28:38 min., grades 7-adult.

"Landing on the Moon;" 1966; NASA HQK-SR2, sound, black and white, 28:17 min., grades 7-adult.

"Power for the Moonship;" 1966; NASA HQK-SR4, sound, B&W, 28:23 min., grades 7-adult.

"Project Apollo - Manned Flight to the Moon;" 1963; NASA HQ 455, sound, color, 13 min., grades 6-adult.

"Room at the Top;" 1966; NASA HQK-SR7; sound, B&W, 28:13 min., grades 7-adult.

TOPIC 5.08

(7-9)

The Orbiting Astronomical Observatory (OAO) is an unmanned satellite designed to give astronomers their first sustained look into the universe from above the obscuring and distorting effects of the Earth's atmosphere.

LEARNING ACTIVITIES

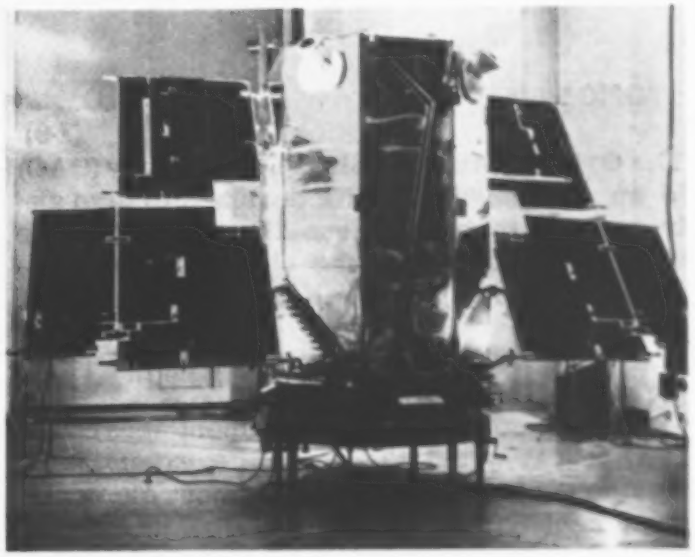
The highly sophisticated equipment aboard the OAO to carry out the scientific experiments may be demonstrated by using more elemental equipment.

1. Special ultraviolet telescopes and associated electronics are used on the OAO to study ultraviolet light from stars and nebulae.

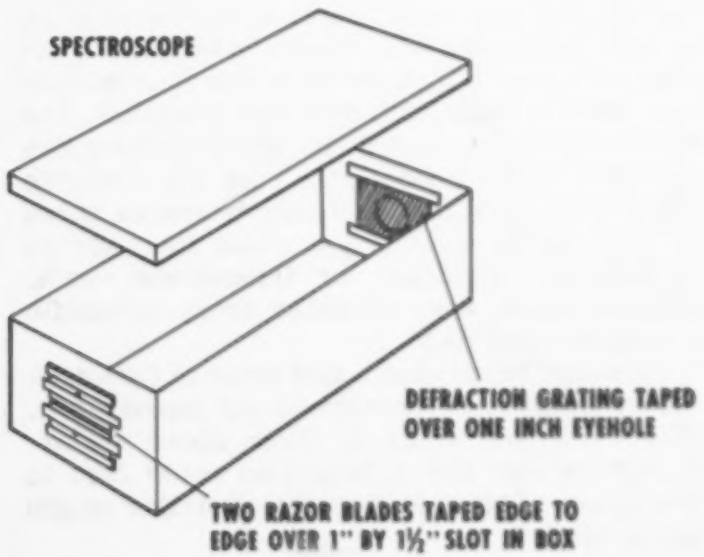
Most students are fascinated by the study of the visible spectrum. "Roy G. Biv" is commonly used to help the students remember that Red, Orange, Yellow, Green, Blue, Indigo, and Violet make up the visible spectrum. Use a prism or diffraction grating or discuss a rainbow to demonstrate what white light is made up of. You may then continue your discussion of the electromagnetic spectrum by pointing out that ultraviolet light is near the blue band of the visible light portion of the spectrum. The ultraviolet light causes sun tan or sunburn. Sun glasses protect our eyes from the invisible ultraviolet rays. Students can observe the effect of ultraviolet light if you shine the light on fluorescent minerals or fluorescent chalk. (These items are available from scientific supply companies.)

Remind the students that most of the ultraviolet light cannot penetrate our atmosphere. The OAO will study it from above the atmosphere and this information could lead to revisions of present theories of stellar origin and evolution.

Orbiting Astronomical Observatory



2. The students may now wish to investigate the spectroscope and spectrometer as a follow-up to the above experience.
3. A high energy gamma ray detector device is another instrument that is used on the OAO. Some students will want to do individual research on gamma rays and perhaps report to the class.



4. Additional experiments with the simple glass prism will convey the idea of the spectrum as well. We can distinguish various elements by their light spectrum.

MATERIALS: Mailing tube, aluminum foil, alcohol burner, diffraction grating or prism, scissors, pliers (straightened paper clips).

ELEMENTS: Table salt - sodium chloride; boric acid - baron; copper sulfate - copper; limewater - calcium; lithium; barium; and strontium. The elements can be obtained from a local drugstore.

PROCEDURE: Place prism or diffraction grating in one end of the mailing tube. Attach aluminum foil on the other end with elastic. Cut a slit in the aluminum foil. Light the alcohol lamp. Place a clean paper clip in pliers, dip into element to be tested and place over flame. Hold prism end up to eye and observe color spectrum of specific element. Change the paper clip for each element tested.

5. Soft X-rays will also be studied by the OAO. Most students have had X-rays taken in a doctor's or dentist's office, or at the hospital.

You may borrow a Civil Defense Geiger counter and demonstrate the presence, in the classroom, of various types of radiation. Cosmic rays can be counted, a radioactive source borrowed from the Civil Defense or from your high school biology teacher. Students may be wearing a wristwatch or have an old alarm clock which has radium coated numbers on it. Use the Geiger counter to prove that this invisible radiation does exist.

Gamma rays can also be detected by a Geiger counter.

Notice the change in the volume of the "clicks" and the change in their frequency as you vary the distance between the Geiger counter and the radioactive source.

REINFORCEMENT

Astronomy has come a long way in the four hundred years since the telescope was invented. Scientists believe that comparable progress will be made in the next decade with astronomical instruments in orbit, or perhaps on the Moon.

The orbiting observatories, such as the OAO, are designed to collect the important information about the sun and the stars which cannot penetrate the Earth's atmosphere.

Detailed studies of the electromagnetic spectrum in the infrared and ultraviolet light, the longest radio waves, and the X-ray and gamma ray regions must be made beyond the atmosphere of the Earth. These studies will enable astronomers to define better the chemical composition, pressure and density of stellar objects.

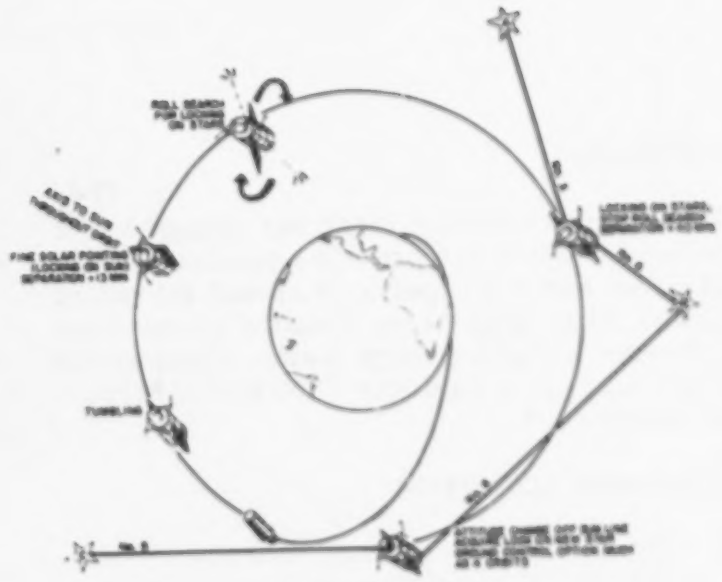
The OAO is the largest of the NASA scientific satellites under development and weighs nearly four thousand pounds. It is also the most electronically complex unmanned spacecraft ever developed by the U.S. It contains more than 440,000 separate parts and 30 miles of electrical wiring.

One thousand pounds of the weight is electronic astronomical observing instruments. It is a 10-foot long, eight-sided cylinder, seven feet wide. With the solar panels extended, the overall width of the spacecraft is 21 feet.

Future OAO spacecraft will have such a precise control system for pointing the scientific instruments that it could look at the width of a pencil 10 miles away. This precision is possible because of the six telescope star trackers mounted on the main body of the spacecraft.

Telescopes aboard the spacecraft will be making studies of stars and nebulae in the ultraviolet spectrum not visible from the Earth. There will also be experiments which are concerned with the study of X-ray and gamma ray spectral regions.

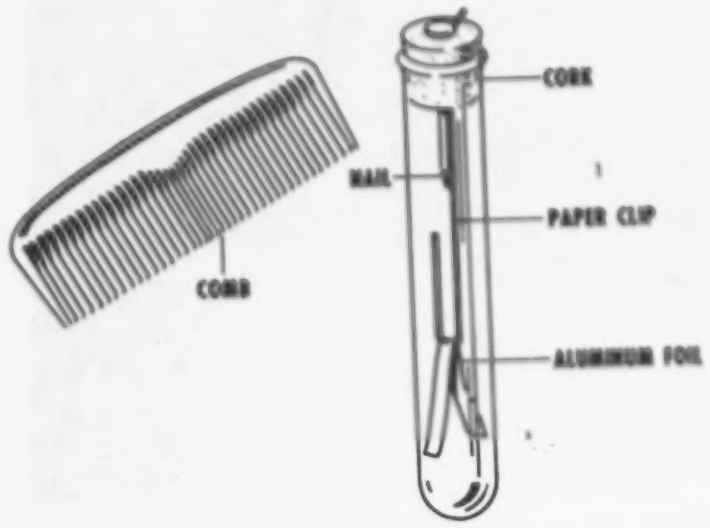
Astronomers want to learn more about the birth of stars, their chemical composition, and whether the distant galaxies are different from the near ones. The OAO will help up map certain parts of the sky now hidden by direct clouds. Clearer view of the planets will also be possible.



OAO STAR ACQUISITION

Perhaps advanced versions of the OAO will determine whether there are planets revolving around some of the stars.

Observations such as these could lead our scientists to basic discoveries about the nature of the Universe. After all, the "radio" telescopes were first used to study our heavens about 20 years ago, and almost immediately a new class of astronomical objects were discovered--the so-called "radio stars". The OAO may make similar or even more important discoveries for us.



1. You can build equipment to detect radiation.

A. The Electroscope

MATERIALS: Test tube, small cork, small nail, paper clip, aluminum foil strips, alcohol, and glue.

PROCEDURE: Push nail and paper clip through cork together. Take aluminum gum wrapper and cut in half, lengthwise (1/2" x 3"). Soak strips in alcohol to dissolve glue and peel off paper backing. Assemble as illustrated: nail, cork, paper clip--touching nail, test tube; aluminum foil--glued onto paper clip. Carefully assemble and proceed. Take a comb and rub it on some wool and touch it to the nail sticking out of the test tube. Note what happens to the foil leaves.

EXPLANATION: Rubbing comb on wool generates static electricity, covering the comb with extra electrons. Touching the nail transfers the electrons down the nail to the foil halves. Because equal charges repel (negative and negative), the foil halves push away from each other and spread apart. Rubbing a glass rod on a polyethylene plastic bag will remove electrons and charge the rod positive. Touching the nail with the rod will also spread the foil halves.

Over a period of time the halves will collapse. This is a result, in part, of cosmic rays streaming through the jar, ionizing some of the air, discharging the foil. The collapse speed is a measure of the number of cosmic rays entering the jar. Other forms of radiation which normally are not present will cause the same result. Hold up a radium dial wristwatch to the glass bottle. The watch radiation will collapse the foil halves, also.

This type of instrument is included on many radiation-studying satellites.

RELATED QUESTIONS

a. Because some strong types of radiation are very harmful, why is it necessary to explore space with unmanned satellites before sending up our astronauts?

b. What results would you expect to happen if a solar storm were to errupt on the sun? Is it necessary then, to constantly watch the sun when planning future manned space flights?

c. What is a cosmic ray? A cosmic ray is an atom (primarily hydrogen or helium) that has lost all of its electrons and is traveling at speeds close to that of the speed of light - 186,000 miles/sec.

d. What is ionization? Ionization is the act of removing some electrons from an atom making the atom charged.

B. Atomic Viewer

MATERIALS: One gr. of zinc sulfide from drugstore
An old, glow in the dark, clock face
2 (2" x 2") glass slides
Empty salt shaker

PROCEDURE: Take clock face and carefully scrape off one numeral; paint in numeral containing a radium salt. Put a gram of zinc sulfide in an empty salt shaker; add the scraped paint and mix together. Carefully shake out a light dusting onto a glass slide. Cover with another slide and tape together around the edges. Take into a darkened room and let your eyes adjust. Hold slide up to your eyes and see tiny flashes of light in the powder - these flashes are a direct result of a radium atom splitting and emitting radiation. A small magnifying glass may help to spot the flashes.

EXPLANATION: Radium atoms are radioactive and eventually throw off pieces of the nucleons. These high speed pieces occasionally slam into sulfur atoms. The collisions result in flashes of light which are faintly visible.

The number of flashes are a direct measure of the radiation produced. Cosmic rays will cause the same effect but because they are far less frequent, compared with the number of neutrons, the number of flares due to cosmic rays are almost negligible.

This type of instrument, called a scintillation counter, is used on many of our radiation studying satellites and space probes.
RELATED QUESTIONS:

a. Radium dial wrist watches will glow in the dark. Even if one was kept in a dark room for many days, the dial will still glow faintly. From what you have already seen, what would you assume was causing it to glow?

b. What is radioactivity? An atom is radioactive if it has a tendancy to break up into smaller pieces. These pieces - electrons, protons, and neutrons, or groups of them travel at very high speeds. When they strike human tissue they can cause extensive damage. Why, then, is it necessary to use instruments such as scintillation counters on our unmanned satellites before we send up our astronauts?
NOTE: Even though the amount of radium in a paint numeral is very small, it is still dangerous. Therefore, DO NOT TASTE IT! Wash out the salt shaker as a further precaution also.

C. Cloud Chamber

MATERIALS: Plastic ice cream container
Black flat paint
Desk blotter
Flashlight
Methyl alcohol
Dry ice (1/2 lb. - 1 lb.)
Cotton
Glue
Source (radium)

PROCEDURE: Paint bottom of container black. Cut strip of blotter to fit around inside of container, touching half the container. When ready, pour in 1/8'' of alcohol in bottom of container and saturate blotter. Place source in bottom of container. Shine a beam from a light source, such as a slide projector or flashlight, through the container and look across the beam against the black background of the blotter. Eventually, as the container cools, little cloud trails will appear in the beam. When they stop, resoak the blotter and repeat procedure.

EXPLANATION: Once the cloud chamber is completed and the alcohol starts to cool, the alcohol vapor at the bottom of the jar eventually reaches a point of supersaturation. This is the point at which its temperature is cool enought to change it from a gas to a liquid but because there is nothing for it to form droplets around (dust, etc.), it continues to remain a gas.

When a cosmic ray passes through, it ionizes a path of air in the jar. Alcohol vapor quickly condenses into small droplets or clouds along these paths, making them visible. Therefore, even though we can't see the rays, we can see where they have been.

By the use of huge magnets, our nuclear scientist can deflect the rays. The amount and direction of the deflection tells them the charge and weight of the rays.
RELATED QUESTIONS:

a. What additional piece of information are we able to obtain with a cloud chamber that an electroscope or a scintillation viewer could not obtain? (Direction of ray)

b. Hold up a radium dial wristwatch to the side of the container. Does the dial emit radiation? Put the back of the watch up to the jar and compare the result with the front.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6 Space - The New Frontier
NF-29 Orbiting Solar Observatory

Films:

"Window on the Cosmos;" 1966; NASA HQK-SR12, sound, black and white, 28:55 min., grades 7-adult.

"The Universe;" 1960; NASA HQa-91, sound, black and white, 28 min., grades 7-adult.

"Missiles, Rockets, and Satellites;" 1959; NASA HQa-14, sound, black and white, 29 min., grades 7-adult.

TOPIC 5.09

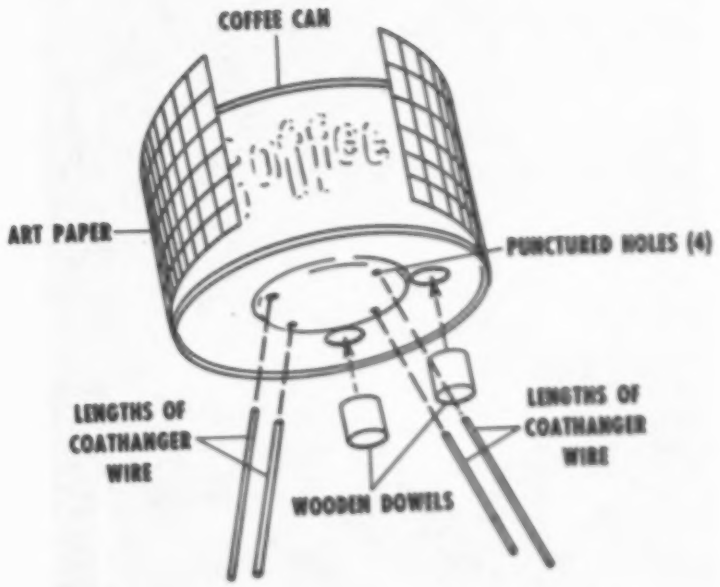
(7-9)

Tiros and Nimbus are satellites equipped with television which can provide a precise picture of cloud and storm patterns around the entire globe. They also carry sensors to measure infra-red radiant energy. Later, Tiros satellites used APT Cameras (Automatic Picture Transmission).

LEARNING ACTIVITIES

1. Build a Tiros weather satellite model.
MATERIALS: Coffee can, coat hanger, two wooden dowels (1'' dia. preferred), art paper, tempera paint (blue and white).

Tiros



PROCEDURE: Puncture coffee can on bottom with four holes. Cut coat hangers to desired length (the distance between any two holes) and bend to form a square "U". Insert bent hangers through holes. Cut wooden dowels and glue on the bottom of coffee can 120° apart. Cut art paper to a size necessary to cover sides of can. Paint paper in blue and white checkerboard pattern to resemble solar cells. Discuss Tiros' contributions and future possibilities.

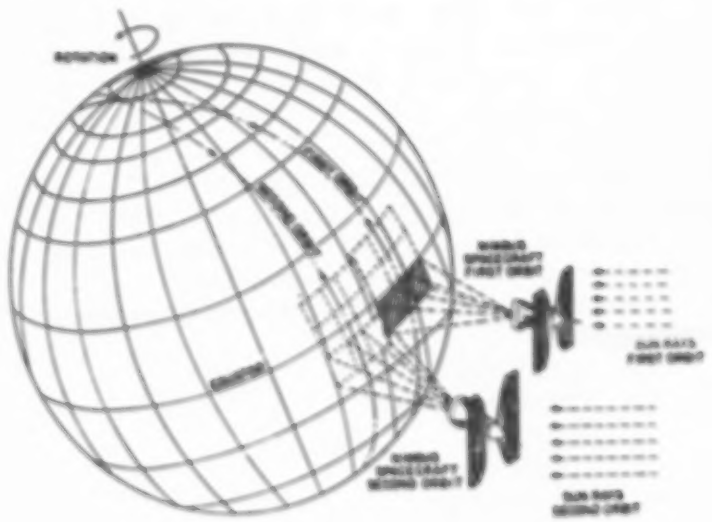
2. Discuss infra-red radiation and its location in the electromagnetic spectrum. Also, what is the relationship between the ultraviolet and the infra-red radiation?

REINFORCEMENT

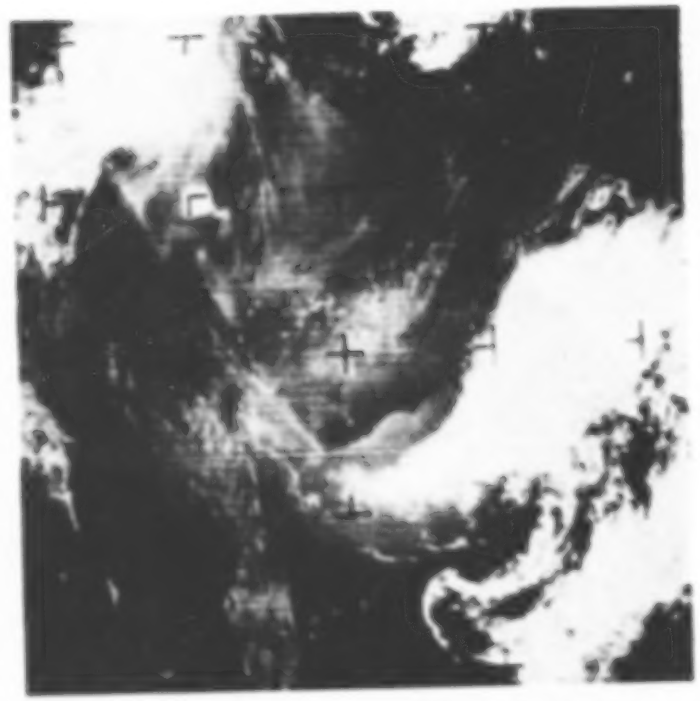
The name TIROS is an acronym for Television Infrared Observational Satellite. It weighs about 300 pounds and is about 20 inches high and 42 inches in diameter.

TIROS contains cameras with vidicon tubes. An electron beam converts each picture on the vidicon tube into a TV-type signal which can be immediately transmitted to a ground station or stored on magnetic video tape. Once received, the ground station has equipment which can reconstruct the picture from the TV signals. Once the transmission is made, the video tape is erased and can be used again.

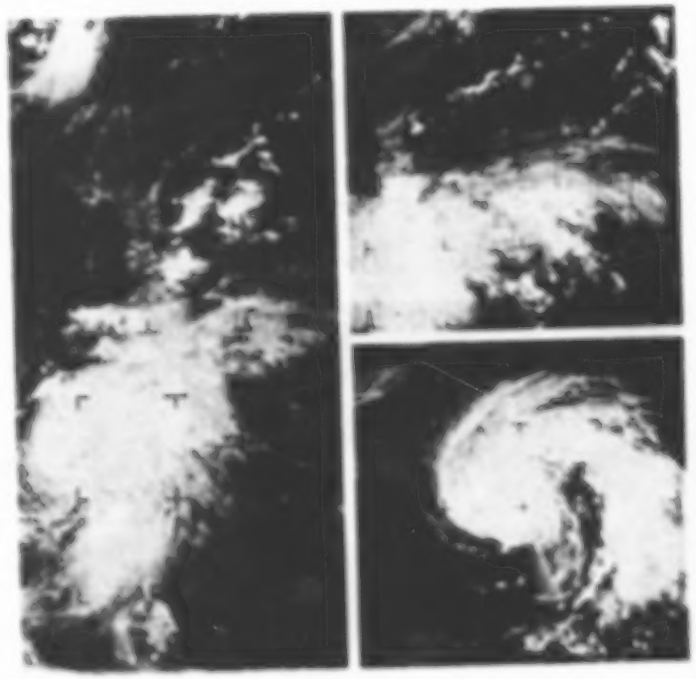
The satellite also contains radiometers which measure the infra-red (heat) radiation from the Earth. The information is stored on tape recorders and then transmitted to ground stations. This data helps us understand how the radiant energy is absorbed and reflected by the Earth's atmosphere.

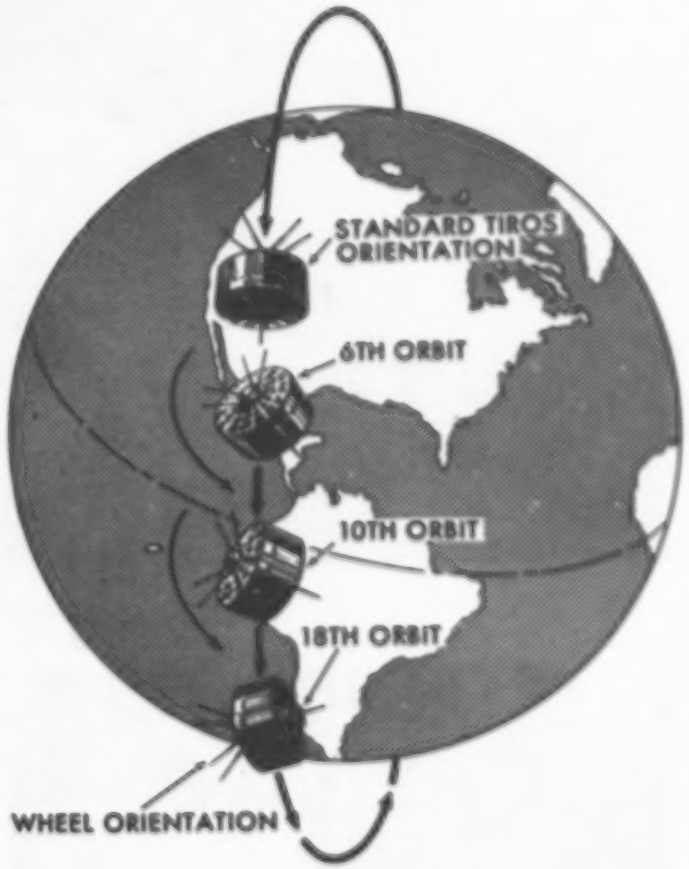


Eastern Seaboard Photo-Nimbus II

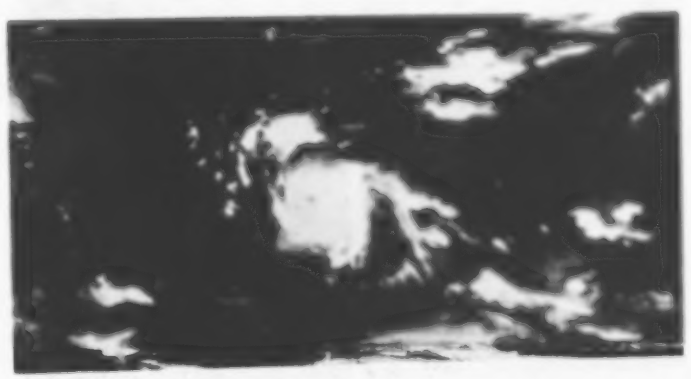


Nimbus-Hurricane Photos





Typhoon "Irma" from Nimbus II



The early Tiros satellites were space oriented. Their TV cameras spent most of their time looking away from the Earth and into space.

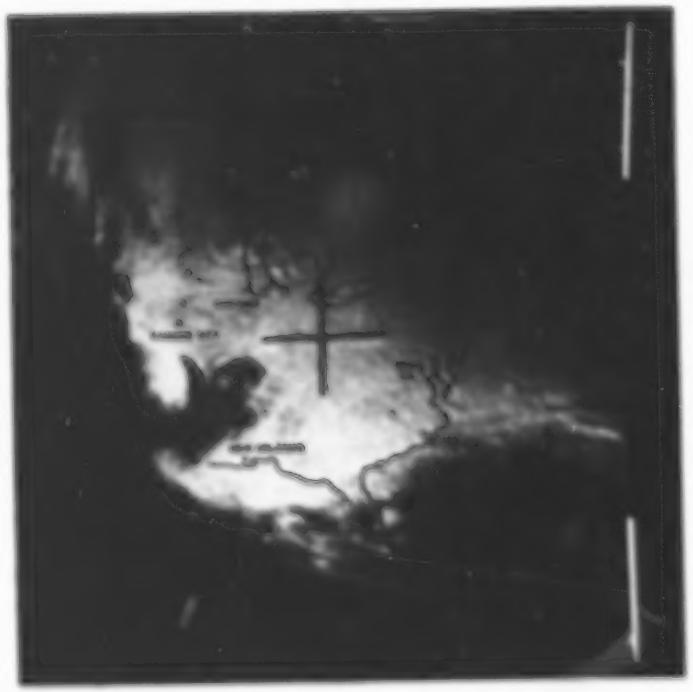
The second generation weather satellite, Nimbus, was designed, built, launched, and operated in order to have a fully instrumented, earth-oriented, weather laboratory in space. "Nimbus", in meteorology, is a rain cloud formation which covers the entire sky.

Nimbus is larger and more complex than Tiros. With the HRIR, High Resolution Infrared Radiometer, Nimbus can, in effect, make photographs of cloud cover at night time. It also has the APT system Automatic Picture Transmission, which enables any ground station anywhere in the world, with proper equipment, to receive and reproduce the cloud cover photograph facsimile as the satellite passes over the country.

The Tiros satellite was modified in order to increase the coverage of world cloud cover. In 1965, Tiros IX was launched. It was the first Tiros "cartwheel" satellite. In 1966, the TOS system was initiated (Tiros Operational Satellite) and was called ESSA I (the Environmental Survey Satellite).

1. When you take your students on a visit to the Weather Bureau, ask them to discuss the APT, Automatic Picture Transmission, with the students. Find out how airlines are making use of the system.
2. Most weather stations using the APT system destroy the charts made as a result of the nephanalysis of the APT readouts. Ask them to save some for your students.
3. Discuss the overall importance of weather satellites to:
   a. Agriculture
   b. Transportation
   c. Industries
   d. Tourists
   e. Meteorology

IX
Tiros Photo



REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-27 Meteorological Satellites and Sounding Rockets

Films:

"Tiros II - Experimental Weather Satellite;" 1961; NASA HQa-31, sound, color, 6 min., grades 7-adult.

"Trial Balance;" 1965; NASA HQ-123, sound, color, 25 min., grades 9-adult.

"Keeping an Eye on Ginny;" 1965; NASA HQK-136, sound, black and white, 27:03 min., grades 7-adult.

TOPIC 5.10

(7-9)

The sun is a mass of hot gases, composed of a variety of chemical elements. The sun shines because of its own atomic activity. NASA has several scientific satellites which are gathering information about the sun.

LEARNING ACTIVITIES

1. What is a safe way of observing the shape of the sun?

MATERIALS: Commercially smoked glass or exposed X-ray film.

PROCEDURE: Students may observe the sun through the commercially smoked glass or exposed X-ray film. CAUTION: Be sure to observe the sun only through the above materials. Make very sure that the students understand this.

DISCUSSION: What shape does the sun have?

Is the sun giving off light? How does the light from the sun compare with the light from the Moon?

2. NASA is using the Orbiting Solar Observatory (OSO) to study the solar storms and other natural phenomena of the sun.

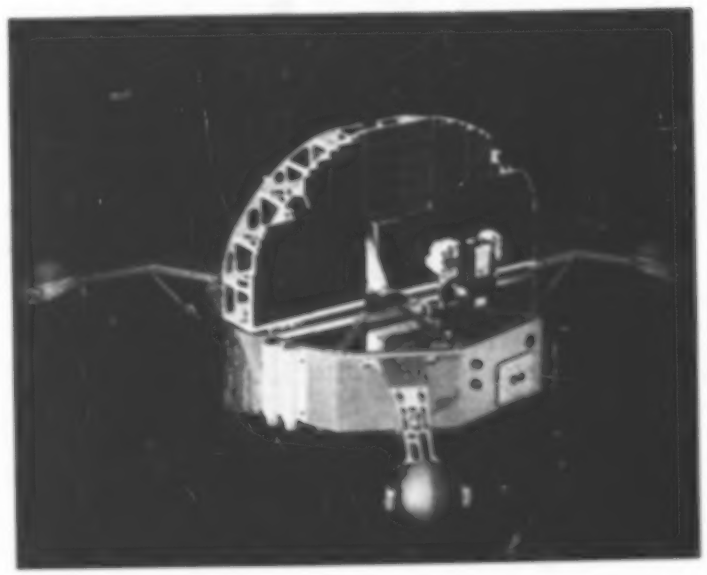
PROBLEM: Solar storms, space hazards.

MATERIALS: Telescope and stand (reflector type), white sheet of paper Directions for Students.

PROCEDURE: DO NOT LOOK AT THE SUN WITH A TELESCOPE. Just as you could burn a hole in a piece of paper, you can burn the retina of your eyes, causing blindness. Take the telescope and focus it on the most distant object visible, e.g., the horizon, the moon, BUT NOT THE SUN. Once focused, point the telescope at the sun by watching its shadow on the ground--NOT BY LOOKING THROUGH IT AT THE SUN. Now, hold a piece of paper a few inches from the eyepiece and re-position the telescope until a 2" or 3" image of the sun appears on the paper. Don't make the image smaller because by doing this it becomes too bright. Finally, focus the eyepiece so that a sharp, clear image is formed.

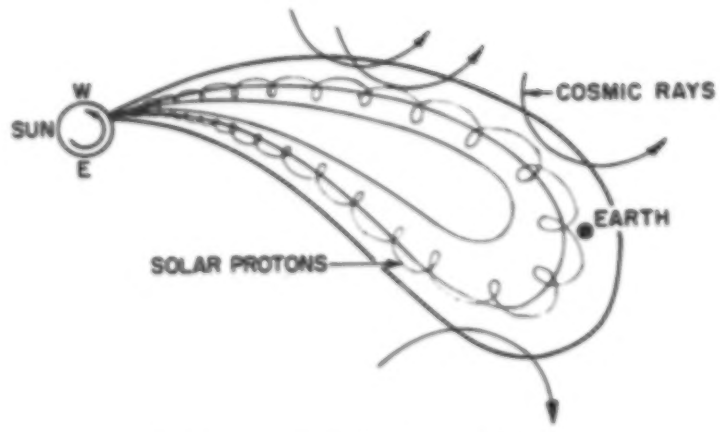
Examine the image on the paper. Small black dots may appear on the image which are sun spots on the surface of the sun. Some large spots measure up to tens of thousands of miles in diameter.

Orbiting Solar Observatory



EXPLANATION: These are violent erruptions on the sun. Because they are cooler than the surrounding areas, they appear darker. These erruptions send out deadly radiation which reaches the earth in 8 1/2 minutes and streams of particles which arrive a day later. We observe the effects of large spots as northern lights and communication disruption.

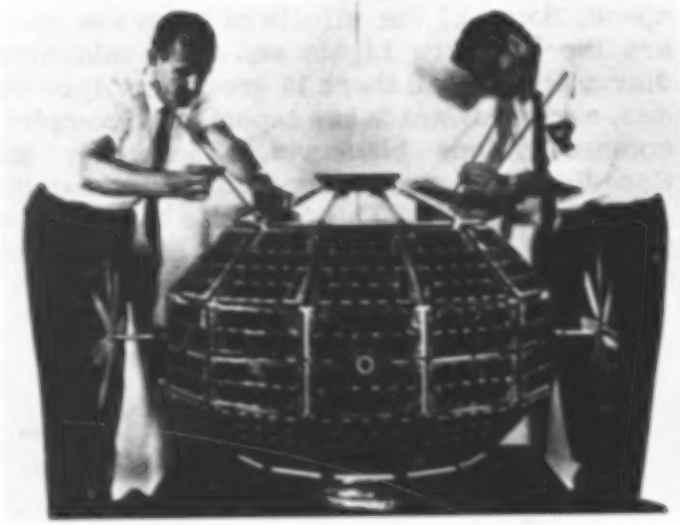
PROPAGATION OF SOLAR DISTURBANCES FROM SUN TO EARTH



AFTER FORBUSH DECREASE*

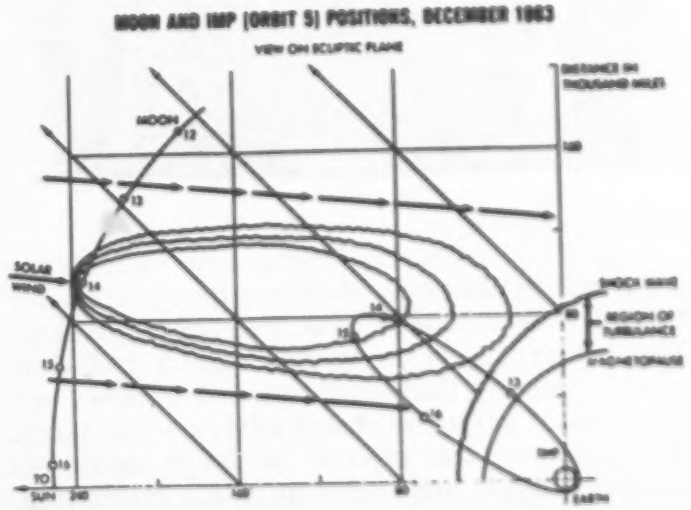
*The observed decrease in *cosmic ray* activity in the earth's atmosphere about a day after a *solar flare*.

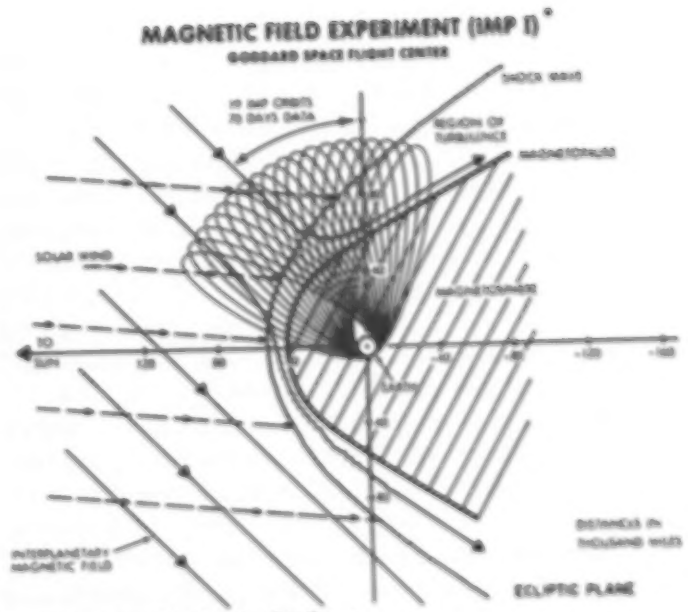
Canadian Satellite "Alouette"



We know that the sun is giving off light because we can see the light it sends us. We could not see it if it did not give off light. At night, it is dark because the sun's light does not shine on our part of the Earth. You can demonstrate this by shining a light on a rotating globe. Best results are obtained in a darkened room. Objects in the heavens which are hot and gaseous, and which give off their own light, are called stars. The sun is the closest star to the Earth. The Orbiting Solar Observatory (OSO) is studying our sun and the Orbiting Astronomical Observatory (OAO) is studying the distant suns or stars.

Sun spots are violent eruptions on the sun. Because they are cooler than the surrounding areas, they appear to be darker. These eruptions send out deadly radiation many miles into space. Some of the effects of large sun spots are the Northern Lights and communications disruptions. When there is great activity on the sun, northern Canada has experienced complete communications blackouts. Therefore, the Canadian Government decided to develop the Alouette satellite. This satellite is a topside ionospheric sounder. It was launched for Canada by the U.S.





*Interplanetary Monitoring Platform

REINFORCEMENT

The sun is an average star. As such, it is an ideal star for us to study. By the use of the Orbiting Solar Observatory (OSO) and other scientific satellites, we can get a great amount of information which helps us to better understand our own star.

Students will want to know more about the sun. They may research and report to the class about the following:

a. Distance of the Earth from the Sun
b. Composition of the Sun
c. Surface and interior temperature of the Sun
d. Mass of the Sun
e. In what ways the Earth is dependent on the Sun, i.e., influence on weather, radio transmissions, solar winds, etc.

EXPLANATION: We generally consider the mean distance between the Earth and the Sun to be 93,000,000 miles. However, we are constantly refining our extraterrestrial measurements as a result of information from our satellites. By the time this guide goes to print, there may well be a new and more accurate measurement available. One astronomical unit, 1 A.U., is commonly used to represent the distance from the Earth to the Sun and is easily converted to the distance in miles.

The elements of hydrogen and helium are the most common constituents of the Sun. Only traces of carbon, nitrogen, or oxygen are believed to be present. The photosphere of the Sun is about 90 per cent hydrogen atoms and 9.9 per cent helium atoms and the mass of the Sun is approximately 1.99×10^{30} kilograms or 1.99×10^{27} metric tons. By comparison, we know that the mass of the Earth is only about 5.09×10^{21} metric tons. The surface temperature of the Sun is believed to be about 10,000°F, while the core temperature is about 10,000,000°F. At this temperature, the hydrogen atoms undergo a nuclear reaction and are changed into helium. Along with the nuclear reaction, large amounts of energy are released and thus the light energy which eventually reaches our Earth.

Our satellites are gathering more information for us about our Sun. Each day our scientists are reducing the complicated data to new meaningful information about the Sun.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Jastrow, Robert; RESULTS OF EXPERIMENTS IN SPACE; NASA, 1962; Supt. of Doc.; Price: $.25.

EP–25 Space Exploration—Why and How
NF–29 Orbiting Solar Observatory

Films:

"Alouette-Canada's First Satellite;" 1963; NASA HQa-94, sound, black and white, 14 min., grades 9-adult.

"Orbiting Solar Observatory;" 1962; NASA HQa-95, sound, color, 26 min., grades 7-adult.

TOPIC 5.11

(7-9)

The spacecraft must be decontaminated so that man may accurately test foreign environment.

LEARNING ACTIVITIES

PROBLEM: Spacecraft decontamination

MATERIALS: Dry beans, (soaked overnight in water), four 1/2 pint milk bottles, water, iodine (3%), alcohol (70%), lysol.

PROCEDURE: Place beans in each bottle and cover them with water. Add the following to each bottle:

Bottle A – iodine
Bottle B – Alcohol
Bottle C – lysol
Bottle D – nothing

Stopper the bottles with cotton and allow them to stand in a warm place for 2 or 3 days. Examine the bottles periodically for cloudiness and odor. Ask the following questions: How do you account for any change in color or odor in each bottle? What difference might we have noted in the results if we used a sterile bottle? Change in temperature? Would sterilization of the beans have helped? Now consider the problems involved in the decontamination of the spacecraft before they are launched. Make a list of possible methods which could be employed.

EXPLANATION: In the search for life forms on other planets, it is necessary that we "sterilize" our spacecraft so that if we do detect life it will not be a form carried by our own exploring devices.

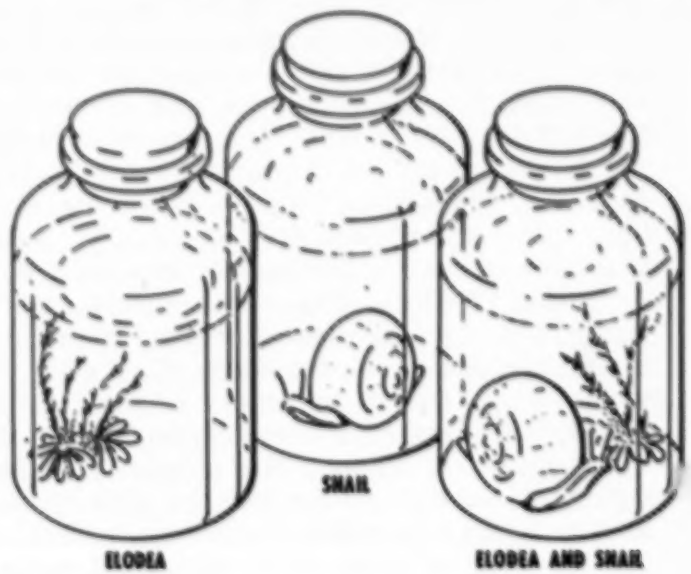
REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

TOPIC 5.12

(7-9)

Ecological Systems: The cabin of the spacecraft must be constructed so that it provides conditions necessary for the physical and mental health of the astronauts. These conditions are: sufficient supply of oxygen and provision for removal of carbon dioxide from the atmosphere of the cabin, food in bite sized pieces and strained forms in squeeze bottles, adequate water supply, control of humidity and odors, circumstances conducive to peace of mind, including devices for communication and outside observation within reach. Astronaut body activity is monitored and relayed to earth.



LEARNING ACTIVITIES

1. PROBLEM: Ecological Systems

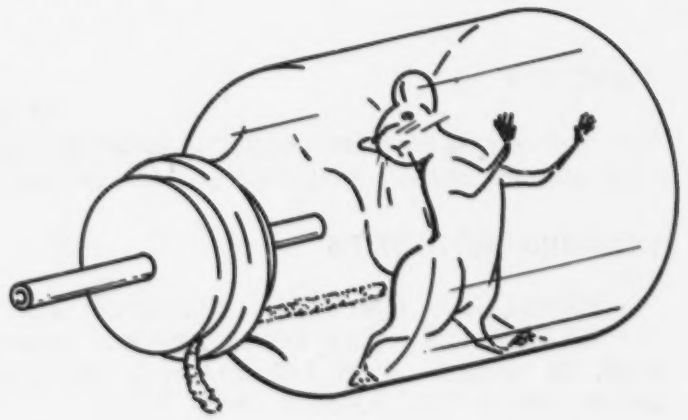
MATERIALS: Three bottles or jars with tight covers, aquarium plants, aquarium snails, aquarium water, dictionary.

PROCEDURE: Fill the three bottles with aquarium water. Into each jar place the following: Jar A - aquarium plants; Jar B - aquarium snails; Jar C - plants and snails; add more aquarium water so that each jar overflows. Cover each jar tightly and allow them to stand for a few days. Ask: what is the condition of the living organism in each jar after approximately three to five days? Relate each jar to possible conditions in a manned spacecraft. Discuss reasonable conditions you believe should exist in a manned spacecraft and explain the reason for including each. (food, oxygen, temperature, light, etc.) Discuss the "closed ecological system" and what is done in a manned spacecraft.

2. PROBLEM: Cabin atmosphere - oxygen

MATERIALS: 1/2 pint milk bottle, pipe cleaners, glass tube, ink, 1-hole rubber stopper, calcium hydroxide ($Ca(OH)_2$) small animals, (mouse, cockroaches, crickets, etc.)

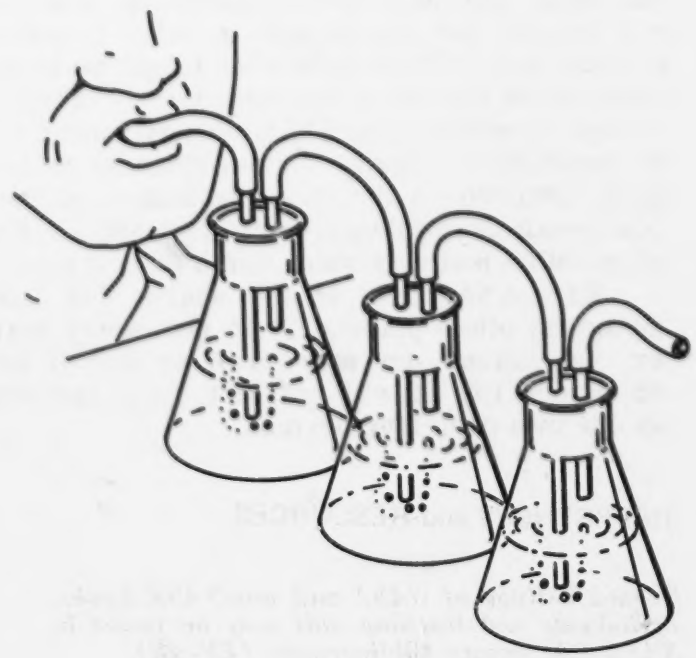
PROCEDURE: Place the animal in the bottle. Place a pipe cleaner soaked in calcium hydroxide down into the bottle ($Ca(OH)_2$) absorbs CO_2. Insert the glass tubing into the stopper allowing approximately two-thirds of it to extend above the top. Now stopper the bottle tightly in such a manner that the pipe cleaner still remains suspended. Apply a minute amount of ink to tip of glass tube, wiping off excess. Observe the movement of this ink marker.



EXPLANATION: It is necessary to know the amount and rate of oxygen usage in the manned spacecraft in order to properly regulate the cabin atmosphere.

3. PROBLEM: Cabin atmosphere - Carbon Dioxide.

MATERIALS: Three 1/2-pint milk bottles (or flasks), glass tubing, rubber tubing,



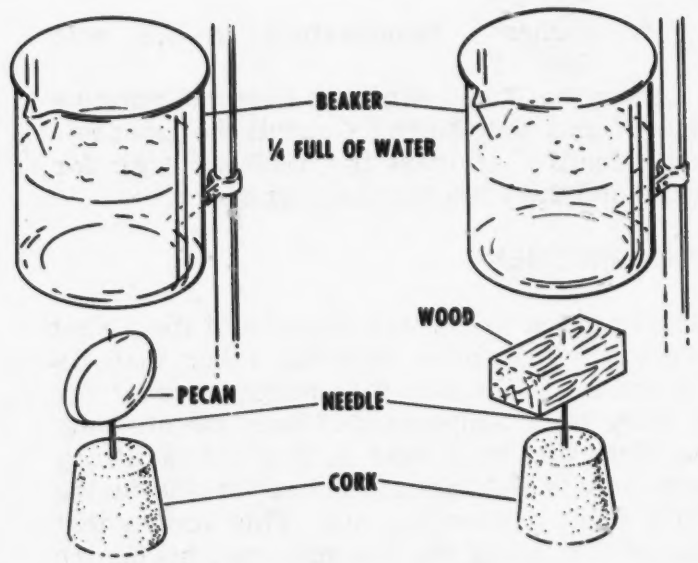
three two-hole rubber stoppers that fit the bottles, lime water ($Ca(OH)_2$).

PROCEDURE: Assemble the glass tubing, rubber stoppers, and rubber tubing, one bottle connected to the other by the glass and rubber tubing inserted in the holes in the rubber stoppers. Add enough lime water to each bottle to cover the end of the glass tube. Exhale a couple of breaths through the rubber tube. The exhaled air will pass from one bottle to another. Observe the color changes of the lime water. Ask the question, "How do you account for the color changes in the lime water?". Describe a similar system that might be used in a manned spacecraft.

EXPLANATION: It is necessary to remove CO_2 from the cabin atmosphere within a manned spacecraft.

4. Expose many kinds of food to extremes of heat and cold.
5. Compare methods of preservation of food in terms of weight, flavor, appearance, etc.
6. Prepare a balanced meal with a blender. Put the food into plastic bags. Eat as an astronaut would eat by squeezing the bag. Note the difficulties.
7. Have several pupils stand on their heads. Have them try to eat a cracker and drink milk through a straw while in this position. Note that gravity is not necessary for swallowing.
8. Encourage the children to bring in dehydrated foods. Explore the amount of water needed to reconstitute them.
9. PROBLEM: Measuring the heat energy in an astronaut's diet.

MATERIALS: Two large corks, pecan nuts, two needles, two beakers (250cc), water, piece of dry, soft wood, ring stands, two thermometers.



PROCEDURE: Place a needle in each cork and mount the pecan nut on the point of one needle and the piece of wood on the other. Place each beaker on a ring stand at the same level. Fill the beakers one-quarter full of water which is of the same temperature. Set fire to both the nut and the wood and place them under the beakers. Record the highest temperature reached by each and the length of time each burned.

EXPLANATION: The diet of an astronaut must be specially considered to anticipate the amount of heat energy released in the normal digestion of food as versus the amount needed in a weightless, inactive space environment.

10. Note information on weightlessness and handling of liquids in the preceeding section.

REINFORCEMENT

1. Observe a drop of water as it drops through oil in a test tube.
2. Distill water by boiling it in a flask fitted with one-hole stopper containing a glass tube and a length of rubber tubing. Lay tubing across a tray of ice cubes and collect drops of water in a container placed under the end of the tubing.
3. Demonstrate the filtration of water by placing about two inches of fine sand in a lamp chimney which has a cloth fastened across the larger end. Pour dirty water on top of the snad. Collect the water as it drips through. Notice that much of the dirt has been removed. Relate the fact that charcoal acts as a filter also, but it filters odor in much the same way.
4. Fill a gallon jug with tap water and let it stand for several weeks. Observe, taste, and discuss the problems associated with storage of water for extended periods of time.
5. Discuss stresses (both psychological and physical) by relating the following experiences to those of the astronauts:

A. We experience anxiety for a short time over the outcome of a ball game, birthday gift, but one learns to control this anxiety so that it does not interfere with one's work and play activities.

B. If accessible to your school plan a visit to a self-contained unit such as a submarine, dirigible or large airplane.

C. Encourage the students to design and build a self-contained unit from cardboard. Have a student spend some time in it and then report on his reactions.

D. Discuss personal experiences in adjustment to a change in social contacts such as a new neighborhood, new school, etc.

E. Discuss the way in which policemen, firemen, lifeguards, etc., act and are anxiety reducers.

6. Discuss with the class:

A. How do we know we are standing upright;

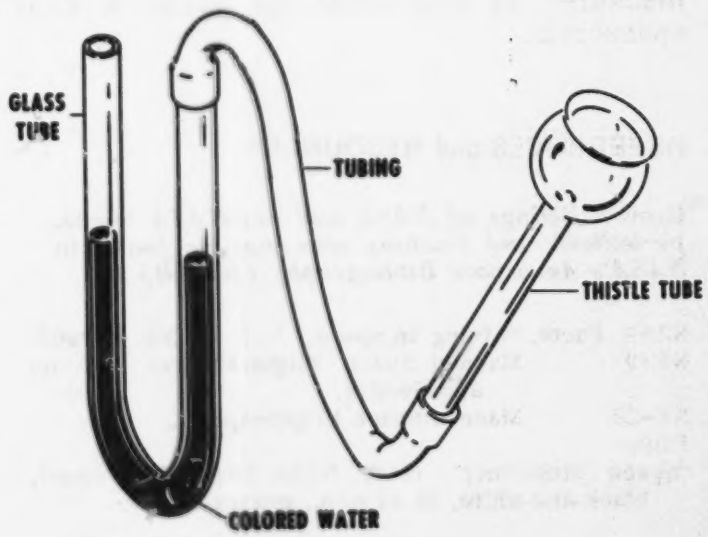
B. Can we still tell our position without the information provided by our eyes? How?

C. Are we able to tell we are moving in a car when our eyes are closed?

7. Have a pupil revolve a partner on a rotating stool. (20 - 25 revolutions) Stop suddenly. Ask him to walk in a particular direction.
8. Examine the feelings of pupils who might have had a hard fall. (The sudden stop after falling sometimes causes severe stress.)
9. PROBLEM: Biological sensors

MATERIALS: Water, colored with ink, U-shaped tube or 2 glass tubes plus rubber tubing, thistle tube, rubber or plastic tubing, ring stand or wooden holder.

PROCEDURE: Half fill a manometer tube with water (a U-shaped tube made from two pieces of glass tubing and a short length of



rubber tubing.) Attach a length of rubber or plastic tubing which has a thistle tube on the end. Have a pupil press the funnel over the carotid artery in his neck, beside the windpipe, or over his heart on the left side of the chest. Observe the action of the liquid in the tube. Discuss body changes of astronauts which should be sent back to earth-based scientists and devices that could be used in doing this.

EXPLANATION: Certain body activities of animals and man can be monitored and measured as they orbit the earth in their spacecraft.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA Facts: "Living in Space;" Vol. III, No. 5, 1966.
NF-9 Manned Space Flight-Project Mercury and Gemini.
NF-23 Manned Space Flight-Apollo.
Film:
"Space Medicine;" 1966; NASA HQK-SR8; sound, black and white, 28:31 min., grades 7-9.

TOPIC 5.13

(7-9)

Satellites are giving us information about planets other than the earth. The Mariner II spacecraft has given us new data about Venus. The Mariner IV spacecraft has given us new data about Mars.

LEARNING ACTIVITIES

1. The students will already have studied the planets and have a good idea of their size and distance from the sun. We can now use this information in a simple demonstration which will lead to a better understanding of temperatures on the planets.

MATERIALS: Lamp with unshielded light bulb, chalkboard for recording temperatures of planets, and a thermometer.

PROCEDURE: Have the students feel the heat coming from the lamp at specific distances. This will illustrate that the distance from the source of heat makes a difference in temperature. Use thermometer to measure the temperatures at various distances. You can follow this experience by having the students investigate the data found in most elementary textbooks. The students should record and report on their findings.

2. Have the students check the most recent world almanac for record temperatures and other weather data on planet Earth. This will better prepare them for understanding temperatures on other planets. Did they find that:
   a. World's official lowest temperature was - 90°F?
   b. World's unofficial lowest temperature was - 108°F?
   c. World's highest surface wind speed was 231 MPH?
   d. World's highest temperature was 136°F?
   e. Lowest temperature on Antarctica was -83°F?
   f. Highest temperature in U.S. was 134°F?
3. Does the World Almanac have information about Venus and Mars? Consult the most recent almanac, at least the 1963 almanac for Venus and the 1966 almanac for Mars.

REINFORCEMENT

Call attention to the temperature of the planet Mercury. Are there reasons other than its closeness to the Sun that might account for its very high temperature? Have the students speculate and then read to find out. Mercury turns only two-thirds around on its axis during a full orbit around the sun. This means that any portion facing the Sun gets very hot before it can rotate away from the heat of the Sun.

The relative size and distances of the planets are difficult to draw to the same scale. Upper grades may use scale models in the classroom by using the scale 8,000 miles to one inch. This will illustrate relative diameters. Use one million miles to one inch to illustrate distances.

MARINER IV: Man's first look at Mars has revealed startling facts that part of the surface is covered with large craters. Diameters of those seen in the photos range from 3 to 75 miles. Probably smaller craters do exist, as well as larger ones. Mariner IV only sampled about one per cent of the Martian surface. Some craters have rims a few hundred feet above and depths a few thousand feet below the rims. Slope of walls seems to be about 10°.

If the sampling is representative, then there would be about 10 thousand craters on Mars compared to a handful on earth. Craters resemble impact craters on Earth and the Moon.

In the southern sub-polar latitudes, mid-winter on Mars, crater rims appeared to have frost.

No trace of "canals" was found in the photos.

No Earth-like mountain chains, great valleys, ocean basins, or continental masses were recognized.

Thus:

a. Mars is more Moon-like than Earth-like.
b. Craters may indicate a very ancient surface-two to five billion years.
c. The state of preservation of the ancient surface may indicate that the Martian atmosphere has always been very thin. Probably not enough water has been present to fill oceans and thus no erosion has occurred as here on Earth.
d. The planet has been long inactive as contrasted with the Earth.
e. No magnetic field or radiation belt detected.

The Mariner IV Trip:
Eight months in space, 325 million miles long, 21 photos were taken. It passed within 6,118 miles of the planet.

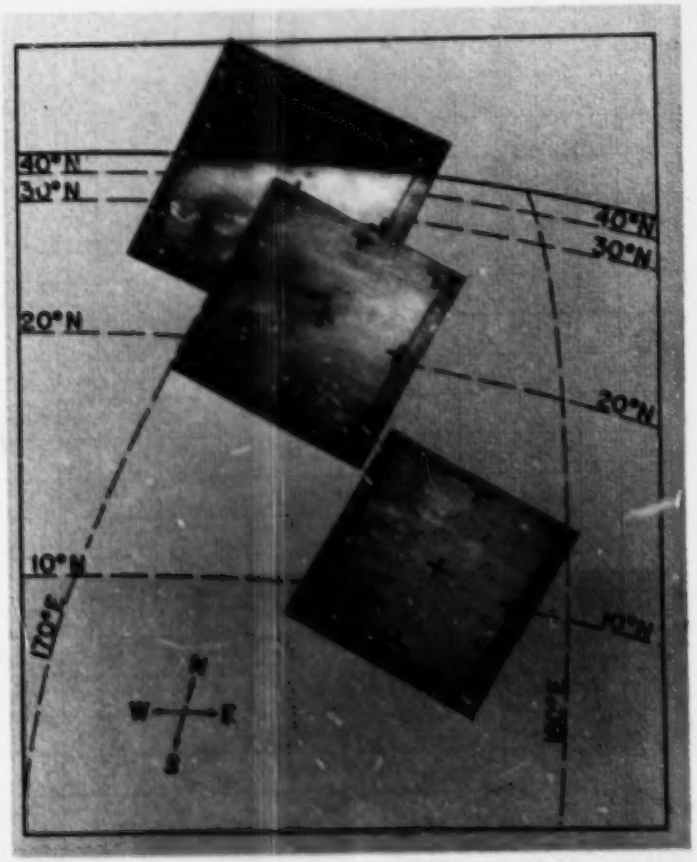
The trip was about 418 million miles to the end of transmission to Earth. The signals back to Earth crossed about 140 million miles. The signal strength was then less than a quintrillionth of a watt (1×10^{-18}).

On October 1, 1965, data stopped. The craft was 191 million miles from Earth and had traveled nearly 419 million miles to its curving trajectory.

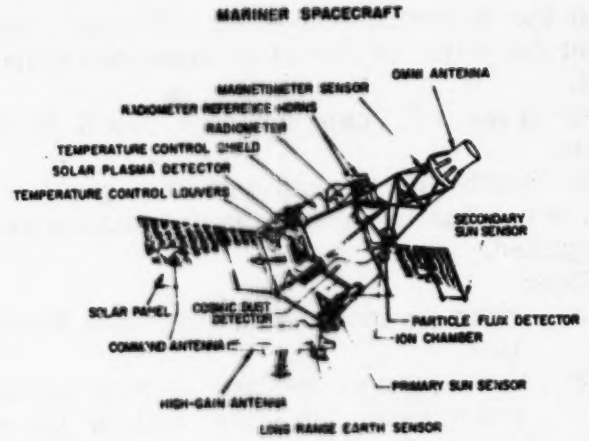
1. Have the students compare Venus with the Earth. Point out that they should use the most recent information available. For instance, mention the fly-by of Venus by Mariner II. This took place on December 14, 1962. Did they find that:

a. The space between the Earth and Venus had 1/10,000 the cosmic dust that we have surrounding the Earth?
b. Solar winds had velocities of 200 to 500 miles per second?
c. Radiation in the vicinity at that time would not have been dangerous for the astronauts?
d. Radar gave us a new figure for the astronautical unit of 92,956,200 miles, plus or minus 500 miles?
e. The mass of Venus compared to the Earth's is 0.8148 (approximately 80 per cent)?
f. Venus rotates very slowly? A day on Venus would be about 225 Earth days long (24-hour day). This would mean that each day or night on Venus would last about 112 1/2 Earth days.

Photos of Martian Surface



g. Venusian clouds probably screen out the sunlight, thus keeping the day side of Venus in twilight?
h. Venus is surrounded by clouds.
i. The clouds do not have the same temperature throughout?
j. The surface temperature of Venus is about 800°F?
K. The atmosphere of Venus is 10 to 30 times more dense than that of the Earth?



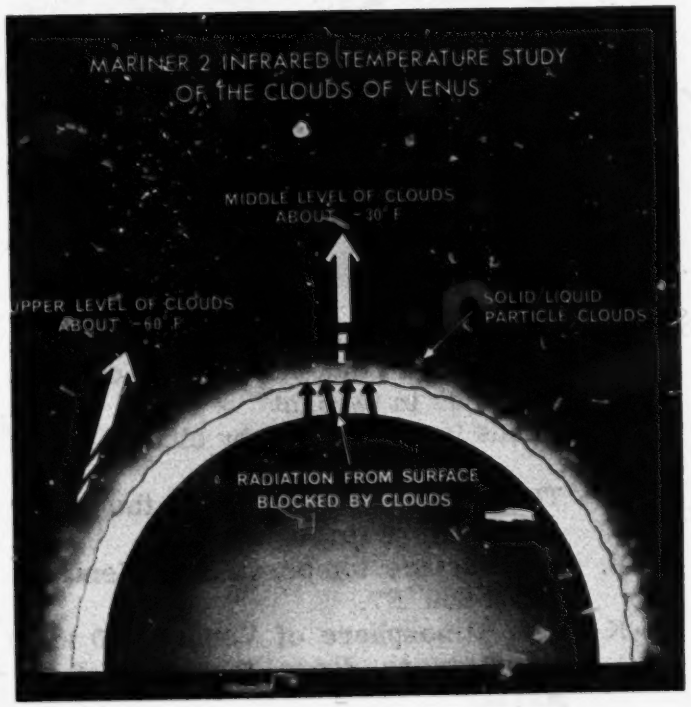
2. Venus shines more brightly than Jupiter, the largest planet of all. Why is this so?

MATERIALS: White paper, a flashlight.

PROCEDURE: Cut two disks from white paper--one for Venus (one inch in diameter) and one for Jupiter (10 inches in diameter). Place both in the room at the following distances: Venus one foot from the eye, two feet from the flashlight; Jupiter 16 feet from the eye and 17 feet from the flashlight. Shine the light on both planets.

EXPLANATION: Venus is closer to the Sun, so the light that is reflected is much brighter. Jupiter is farther away and so appears smaller and less reflective even though it is larger.

3. Have the students report on the latest information available on Mars.



REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-39 Report from Mars: Mariner IV, World Almanac (most recent edition).

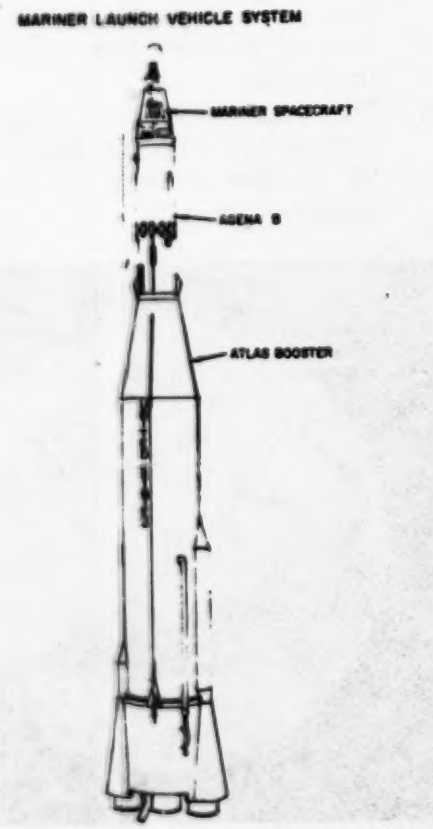
NF-26 A Report from Mariner IV.

Films:

"The Clouds of Venus;" 1963, NASA HQa-82, sound, color, 29 1/2 min., grades 7-adult.

"The Log of Mariner IV;"1966; NASA HQa-159; sound, color, 27 min., grades 7-adult.

"The Search for Extra-Terrestrial Life;" NASA HQK-SR13, sound, black and white, 28:33 min., grades 7-adult.



6. Science: High School

by Paul J. Boylan

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Science: High School

INTRODUCTION

IMPORTANCE OF SPACE SCIENCE INFORMATION IN SCHOOL CURRICULA

In his fascinating story of the inadequacies of school curricula, The Saber-Tooth Curriculum, Harold Benjamin lays bare one of the great problems in education, namely, keeping it up-to-date. This tale of pre-historic schools tells of the techniques of trapping saber-tooth tigers (the digging of pits, luring the animal, etc.), which were continued as required topics even though this beast had long since disappeared from the local scene.

While our modern curricula may not have too many saber-tooth tiger items, there is frequently a genuine time lag and lack of pertinent and current items, especially in the field of science.

Curiosity is the hallmark of the growing child. Too often, however, his curiosity is stifled or thwarted by the topics and studies of his classroom which seem to bear little or no relationship to the world out of school.

Unless his science teacher keeps both him and his students up to date through the use of current science periodicals and news items in the classroom, there will seem to be little relevance to what is happening in the child's science room and what he is viewing in the way of science on his television screen.

One great danger, however, lies in the expediency of constantly introducing the new and exciting topics of the day without establishing the fundamental principles that underlie and make such facts as the docking of Agena and Gemini possible.

It is the intention of the following suggestions to supply a basis for keeping the present-day science curriculum up to date and meaningful and at the same time establishing the solid basis of science principles which will permit something more than the shallow acquaintance with the new.

SPACE EXPLORATION AND HIGH SCHOOL SCIENCE EDUCATION

For the teacher and the student, aerospace is an explorer's field above the air and sea, where prospects of new knowledge are the incentives to exciting careers.

Space exploration is a natural outcome of at least seven developments that nurtured its arrival and are keeping it underway. These same developments have already altered the boundaries of education.

We are not waiting for our own evolution, but are inventing it.

Evolution is promising, but slow. The man who can see a bacterium with his unaided eyes has not been born, but men using invented long eye-extensions, called microscopes, have been watching bacteria for years.

There has not been a person born sensitive to the presence of radio-activity, but thousands are employed in its management by using instruments invented to convert it to visible light and audible sound.

Electromagnetic waves, both too long and too short to be seen, have been brought into usefulness by people using invented sensitivities.

Information can be aimed at, projected to, and reflected from, objects in space.

Energy from outside ourselves is part of our capital. We carried wood and coal and pumped oil for fuel fires where we needed heat to run engines. We also drew heat from elements changing structure in slow atomic bombs. Our heat engines moved conductors through magnetic fields to make streams of electrons called electric currents. Other electron streams were taken from ions in chemicals reacting in cells and batteries. Electric currents from any source are now made into waves of precisely-governed frequencies and these waves modulated to carry information on Earth and into space and back.

We have now learned how to live and learn for a while in places we were not born to survive in.

We packaged our essential living conditions and took them with us under water for long periods in submarines and also in the pressurized cabins of aeroplanes. Now we plan to live for a while moving at tremendous speeds in celestial orbits where radiation is intense and gravity and government are missing. Important new knowledge of our world may repay our risks.

Mathematics as a tool of inquiry and production has been speeded and widened.

Problems previously set aside because tedious and exhausting calculations blocked their solution are yielding to the prodding of electrons in computers and auxiliary devices.

Scientists are growing in public favor.

People felt that many scientific discoveries were empty and seldom reached to then. Now engineers and technicians follow discoveries with the inventions needed to set up new processes and make quantities of new products so millions of us can have the benefits of them.

Pre-eminence in technology is a major concern of governments.

Some scientific research of great magnitude and expense is supported by general taxation. The advancement of mankind and the preservation of our own way of life makes us willing to pay to keep research going forward.

The most powerful forces ever possible for us to release can be kept or delivered in small containers.

Space vehicles heavy as school buses full of passengers can be shot into orbits hundreds of miles above us.

These and other developments are always moving on. They merit the attention of everyone now in school who senses the careers being opened in aerospace and the supporting fields related to space exploration.

PLAN OF ORGANIZATION

One of the principal problems which confronted members of the secondary school science group in planning a space education resource guide was to devise a suitable scheme of organization which would permit an interrelationship between topics in science as commonly taught in various secondary schools and those space topics which seem to be important and relevant to the school curriculum.

To put it simply, no matter how important space topics might appear to be to those interested in the field, unless the guide provides a meaningful relationship between these topics and what the teacher commonly presents in his classroom, such a guide would only be another item added to his already overburdened schedule of teaching.

Teacher acceptance and integration and interrelation of space topics into the school curriculum then became a primary goal of this organizational scheme.

The plan for senior high school would include:

SPACE QUESTIONS (to stimulate and arouse interest in the field)

SPACE TOPICS (outstanding space topics which should be emphasized or related to material regularly taught in science curricula)

HIGH SCHOOL SCIENCE - BIOLOGY, CHEMISTRY and PHYSICS (a listing of those topics which would provide a basis for introducting or relating space concepts)

TOPIC DEVELOPMENT (selection of a particular related item of science which would be "spelled out" in terms of a thorough space exposition of the item with possible activities, methods of presentation, supplementary readings, suggested films, projects, and related topics.)

SPACE EDUCATION QUESTIONS

The following questions give examples of topic areas for space education discussions.

I. WHY SHOULD WE PUT A MAN INTO SPACE?
   - A. How are particular interests served by such a project?
     1. Military /civilian
     2. Research
     3. Knowledge

II. HOW DO WE PUT A MAN INTO SPACE?
   - A. What are the space systems involved?
   - B. What are the problems of space travel?

III. HOW DO WE KEEP A MAN IN SPACE?
   - A. What are man's food and water needs?
   - B. What particular problems does man face in outer space?
     1. Acceleration
     2. Weightlessness
     3. Radiation
   - C. Requirements of a suitable atmosphere

IV. HOW DO WE RETURN A MAN FROM SPACE?
   - A. Re-launch problems
   - B. Re-entry problems

SPACE TOPICS

I. THE UNIVERSE
   - A. Our solar system
     1. Sun, planets, moon, planetoids, comets, and meteorites
   - B. Beyond our solar system

II. SPACE ENVIRONMENT
   - A. Radiation belts
   - B. Types of radiation
     1. Solar plasma and high energy particles
     2. Cosmic rays
   - C. Magnetic fields
   - D. Man's air, food, and water needs
   - E. Acceleration, gravity, weightlessness, radiation problems

III. SPACE TRAVEL
   - A. Planetary motion
   - B. Earth satellites
   - C. Escape speeds
   - D. Re-entry problems

IV. SPACE SYSTEMS
   - A. Propulsion principles
   - B. Power systems
     1. Electrical
     2. Electrochemical
     3. Mechanical

V. SPACE CRAFT
   - A. Structure
   - B. Materials
   - C. Guidance and Control
   - D. Communication

SPACE RELATED PHYSICS TOPICS

I. MEASUREMENT
II. MASS AND WEIGHT
III. FORCE AND MOTION
IV. STRUCTURE AND MATERIALS
V. HEAT
VI. MAGNETISM AND ELECTRICITY
VII. LIGHT AND SOUND WAVES
VIII. RADIO AND TELEVISION
IX. RADIATION

SPACE RELATED CHEMISTRY TOPICS

I. STRUCTURE AND STATES OF MATTER
II. CHEMICAL REACTIONS
III. ELEMENTS, MIXTURES AND COMPOUNDS
IV. THE PERIODIC TABLE
V. IONIZATION, SOLUTION AND EQUILIBRA
VI. NUCLEAR CHEMISTRY
VII. ORGANIC CHEMISTRY

SPACE RELATED BIOLOGY TOPICS

I. LIVING MATTER AND THE CELL PRINCIPLE
II. BASIC STRUCTURE AND ORGANIZATION
III. TYPES OF LIVING ORGANISMS
IV. METABOLISM AND DIGESTION
V. EXCRETION AND DIGESTION
VI. RESPIRATION
VII. CIRCULATION
VIII. GENETICS AND HEREDITY
IX. ECOLOGY

TOPIC 6.01 **(10-12)**

Biology: Circulation

Circulation of materials, food, oxygen and body substances such as hormones, etc., is a process common to all animals and plants. The process of circulation is far more complicated in the higher organism than in the lower ones. The vertebrate circulatory system and especially that of Man is highly developed and though it consists of several parts, the system still performs the basic function of transportation.

What effects the space environment will have on various parts of the circulatory systems and their function is not well known.

LEARNING ACTIVITIES

Check the pulse rate of a person who has been sitting quietly or reclining for 15 or 20 minutes and then check it again after a period of mild activity. Does this give you a clue about what the pulse rate of an astronaut might be while sitting in a weightless condition in his spacecraft? What other factors affect the pulse rate? If equipment is available, check the blood pressure, as well as the pulse rate.

REINFORCEMENT

The action of the heart, blood and vessels in a weightless condition has been shown to be similar to that of a person kept at bed rest for several days. Blood volume actually decreases and the workload of the heart is lowered considerably.

Acceleration stress and its effect on the circulatory system have been widely studied. During rapid acceleration upward (as on lift-off) the astronaut is in a reclining position instead of sitting upright. In the latter position, the heart would not be able to pump sufficient blood to the head because of the amount of "push" downward on the column of blood and a "blackout" would result. A body position at a right angle to the upward thrust will eliminate this possibility.

Discuss what would happen when the astronaut is subjected to rapid deceleration and build-up of "g" forces upon re-entry. The reclining position of the body is again an important factor.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Circulatory Problems Resulting from "Weightlessness," NASA Educational Brief #1004.1; Manned Spacecraft Center, Houston, Texas.

Measures to Overcome the Problems of Postural Hypertension; NASA Educational Brief #1004-B; Manned Spacecraft Center, Houston, Texas.

Film:

"Space Medicine;" 1966; NASA HQK-SR8; sound, black and white, 28:31 min.

TOPIC 6.02 **(10-12)**

Biology: Energy Relationships

The Sun is the source of energy available to living organisms on Earth and plants and animals have developed a mutual relationship based on utilization of this energy. In the hostile environment of space, Man must utilize this relationship in order to maintain life. Energy drawn from the Sun by plants and made available to man in the form of food is still a basic requirement.

LEARNING ACTIVITIES

Observe a sealed aquarium containing plants and animals in a balanced environment. Show how each is dependent on the other.

REINFORCEMENT

The sealed aquarium represents a closed ecological system. A spacecraft is a similar, though not identical to a closed ecological system in that man must carry his environment with him as he travels into space. The following topics might be discussed at some length:

a. How much oxygen is required to sustain a man for one day? How much food? How much water? (In a spacecraft, the astronauts' basic requirements can be met with a daily supply of about two pounds of oxygen, approximately seven pounds of water, and two pounds of food.)
b. What factors might influence daily oxygen, food and water requirements? (Consider such factors as body size, amount of physical activity and temperature of the environment which may affect daily requirements of these items.)

c. Can man carry enough food, water and oxygen in the spacecraft to sustain him on a six-month journey through space? (Probably, though it has not been accomplished. Technologies which will give man this capability are being developed.)

Regenerative Processes and Waste Disposal. It is experimentally possible to recover oxygen from the carbon dioxide exhaled by Man and to recover reusable water from the urine. Solid wastes are presently packaged and disposed of after returning to Earth. On long space journeys, methods to recover usable fractions of the solid wastes are being studied.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NF-27 "Living in Space," Vol. III, No. 5.

Films:

"A Case for Regeneration," Part I, in a series of films titled Living In Space. 12 mins., sound, color, 1965. NASA HQ131-A.

"A Technology for Spacecraft Design," Part III in a series of films titled Living In Space. 1965. 12 mins., sound, color, HQ 131-C, NASA.

TOPIC 6.03

(10-12)

Biology: Stimulus and Response

Irritability is a fundamental characteristic of living matter. It is capable of responding to a stimulus.

1. The relatively slow response of plants to an environmental stimulus is called a tropism.

2. Animal and Plant Rhythms. Organisms on Earth are exposed to a 24-hour day-night cycle, thus animals and plants whose activities undergo regular changes during the 24-hour period are exhibiting a circadian rhythm. Other response cycles may be longer and correspond to a monthly lunar period or even a seasonal (Winter, Spring, Summer or Fall) periodicity.

LEARNING ACTIVITIES

1. Geotropism, the response to gravity, can be illustrated by placing a potted plant on its side and observing the direction of the roots and shoots over a period of two or three weeks.
2. Laboratory demonstration of circadian rhythms is difficult for most high school biology classes. It is possible, however, to ask students to observe animals such as roaches which are typically nocturnal and bees which are diurnal. Plants may also be studied for changes that occur in the flowers and leaves during a day-night cycle.

REINFORCEMENT

Stimulus and Response. All living organisms respond to environmental stimuli. The degree and rapidity of response is variable and depends on a number of factors. Since Earth organisms live in a relatively constant environment as far as gravity (one "g") is concerned, biologists are interested in studying organisms in a weightless (zero "g") environment to observe both short range and long range responses.

a. Will prolonged weightlessness affect the muscular system of an animal? (Yes, possibly because of the lack of stress imposed in a gravity environment. This is one reason for a regimen of exercises proposed for astronauts while in the spacecraft.)
b. Discuss the problem of direction of root and shoot growth in a plant. Do you believe weightlessness will affect this. (Yes, as demonstrated during the Sept., 1967 Biosatellite flight which contributed to previously held theory.)
c. Discuss the possible interruption of liquid transport through a plant due to a weightless condition.
d. Will such basic processes such as mitosis be altered in a state of weightlessness? (Normal mitotic behavior may be altered. Preliminary reports from Soviet biologists indicate this to be the case.)

Animal and Plant Rhythms. Activities of animals and plants show a remarkable periodicity. This rhythm of activity may be influenced by external (exogenous) factors such as temperature and length of periods of light and darkness. It is also believed that certain unidentified internal (endogenous) mechanisms, perhaps hormonal, are also involved.

Discuss the possible effects of a very short (90 minutes) day-night cycle on an astronaut in a spacecraft orbiting the earth.

Describe some circadian rhythms observable in Man. Can these be changed? (Yes, note Man's adaptation to different hours of eating and sleeping when the normal cycle is altered by rapid travel through several time zones here on Earth.) What is the length of light-dark periods on the Moon? (Approximately two weeks.) Do you think man can adapt to this type of day-night cycle? (Yes, though it may cause some discomfort.)

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NF-3 Biosatellites

Film:

"The NASA Biosatellite Program" (Between the Atom and the Star); 1965; sound, color, 28 min.

TOPIC 6.04

(10-12)

Biology: Effects of Radiation

X-rays, gamma rays and cosmic radiation may have lethal effects on organisms if exposure to the radiation is sufficiently great. Lower intensity radiations or less exposure time may result in tissue damage of varying degrees or, if germinal tissue is involved, may lead to increased mutation rates.

LEARNING ACTIVITIES

Although actual irradiation of living matter is usually not feasible in the high school laboratory, one might have a physician or dentist expose seeds to X-rays for varying lengths of time and then study plants grown from the irradiated seed for possible mutations.

REINFORCEMENT

1. Discuss the effects of excessive X-ray or gamma radiation on the human body, which tissues are affected most quickly. (Tissues most sensitive to radiation damage are those such as the skin, bone marrow, lymph glands, and gonads.)
2. What kind of shielding will a spacecraft need in order to protect the astronauts as they travel through the Van Allen radiation belt? (It is believed that the Van Allen belt can be traversed at speeds great enough to avoid long and damaging exposure to the trapped particles.)
3. Discuss the nature of particles trapped in the Van Allen belt.
4. Recent evidence indicates that Mars has no magnetic fields similar to those surrounding the Earth. What significance would this have as to the amount of radiation an astronaut might encounter on a visit to Mars? (An astronaut would undoubtedly be exposed to high levels of radiation and would have to be shielded against the damaging effects.)

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

NF-26 A Report from Mariner IV

TOPIC 6.05

(10-12)

Biology: Detection of Extra-terrestrial Life. In order to detect life on other planets the biologist must use methods which are based on the assumption that such life has a chemical nature similar to living organisms on earth. One such assumption is the presence of organic compounds which react in a manner similar to those found in protoplasm here on earth.

LEARNING ACTIVITIES

1. Test for the presence of an organic compound (starch) in plant tissue by using the iodine test. Check also for sugars using either Fehlings or Benedicts solution
2. It may be useful to illustrate the presence of another organic compound, an enzyme (ptyalin in saliva), which converts starch to sugar.
3. Detection of living organisms not apparent to the naked eye may be demonstrated by placing 1 gram of soil, which contains no visible living matter, in a test tube of sterile nutrient broth. Let stand at room temperature for 24 hours. Examine a drop of the material under the microscope for evidence of living matter.

REINFORCEMENT

1. Detection of life on other planets requires construction of highly sophisticated, automated equipment that will collect and analyze various materials and telemeter the data back to Earth. Several types of these unmanned, automated laboratories have been suggested. All of them depend on the identification of certain characteristics of living matter such as the ability to carry out metabolism and the ability to reproduce.

Identification of extra-terrestrial life by automated laboratories is also based on the biochemical analysis of materials for the presence of certain organic compounds known to be associated with living matter. Finding evidence of proteins, carbohydrates and, more significantly, DNA would be highly suggestive of living matter.

2. Discuss how you might set up an experiment to detect metabolic activity of an organism.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Film:
"The Search for Extra-terrestrial Life," 1966; NASA HQK-SR13, sound, black and white, 28:33 min.

TOPIC 6.06

Biology: Inheritance (10-12)

Characteristics are passed from one generation to the next through germ cells carrying DNA. The principles of heredity form one of the broad bases on which biology rests and every student should be aware of the mechanisms by which hereditary traits are transmitted.

LEARNING ACTIVITIES

1. Obtain cultures of the fruit fly Drosophila from a biological supply company and carry out breeding experiments.
2. Seeds of certain genetic types may also be purchased and planted in the laboratory to observe hereditary traits.

REINFORCEMENT

1. Genes (DNA) are the determiners of hereditary traits and are an integral part of the chromatin material in the nucleus of a cell. Discuss the phenomenon of mutation. What physical factors are known to cause or induce mutations? (X-rays and gamma radiation are known to induce mutations.)
2. Discuss the possibility of increased mutation rates in humans as a result of long space journeys? (The possibility exists but is reduced to near zero with proper shielding.) What is the source of such radiation found in space? (The sun is the primary source) What shielding would be necessary to protect man? (Materials such as aluminum and lead are useful but the thickness will depend on the length of exposure and amount of radiation encountered.)
3. The mutation rate of earth organisms due to radiation from outer space is relatively low. Why? (Very little of such radiation reaches earth.) What protects them? (The earth's magnetic field as well as the blanket of atmosphere serve as protection against radiation from space).

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

TOPIC 6.07

(10-12)

Biology: Evolution

Since the origin of life some three and one half to four billion years ago, living organisms have undergone a long series of changes (evolution). Changes have been slow but a study of the fossil record reveals a fairly clear picture of the major evolutionary trends in both plants and animals. Generally the mechanisms of evolution involve both natural selection and genetic changes.

LEARNING ACTIVITIES

1. Prepare a chart illustrating some of the modern biochemical theories on the origin of life.
2. Study both animal and plant fossils and discuss their possible ancestral relationships.

REINFORCEMENT

1. The concept of evolution embraces changes in living matter from its formation until the present day. Any study of evolution should include a discussion of how life arose, that is, the biochemical evolution of living matter.
2. What are the basic chemical elements in protoplasm? (The basic elements are: carbon, hydrogen, oxygen and nitrogen).

Discuss some of the theories that explain how and under what conditions living matter was formed by the combining of these elements.

3. If these theories explain the origin of living matter on the planet earth, might the same theories apply to other planets such as Mars, etc? (Yes, we believe the same theories would apply.)

What do you think are the possibilities that if life exists on other planets it followed a course of evolution similar to life on Earth? (We can only speculate, but there are possibilities that a similar course of evolution occurred. How far the evolution has progressed, we have no way of knowing.)

Would living matter on another planet be subject to the same laws of physics and chemistry as on Earth? (Yes, it is believed the same laws would apply.) What effect might the environment have on the course of evolution? (The environment would be a powerful factor in the natural selection process and thus might determine the direction of the evolutionary process.)

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

TOPIC 6.08 **(10-12)**

Physics: Bodes Rule

This empirical rule formulated by J.E. Bode (1747-1826) is a simple means of calculating mean distances from each planet to the Sun. This rule is sometimes referred to as a law; however, it does not as yet have the strength of natural law. Perhaps some of NASA's scientific satellites will help provide the needed strength.

LEARNING ACTIVITIES

1. In order to apply this Rule, we must include the belt of asteroids between Mars and Jupiter as if they occupied the position of a planet.

If we take the numbers 0, 3, 6, 12, 24, 48, 96, etc., doubling each number up to and including 768, the tenth number (nine planets and the belt of asteroids), adding four to each value and dividing by 10, we obtain the distance in astronomical units of each planet from the Sun.

Distance from the Sun (A.U.)

Planet	Actual	Predicted
Mercury	0.4	0.39
Venus	0.7	0.72
Earth	1.0	1.0
Mars	1.6	1.52
-------	2.8	----
Jupiter	5.2	5.2
Saturn	10.0	9.5
Uranus	19.6	19.2
Neptune	38.8	30.1
Pluto	77.2	39.5

2. Use Solar System Chart to give frame of reference for this discussion.
3. Given the above data on the distance of the various planets from the Sun in astronomical units (1 A.U. 93,000,000 miles), can you express, in terms of an equation, the mathematical relationship that exists among the planets with respect to the distance of the planet from the sun? Hint: The distance equals a constant plus the power of another number. (If this exercise is used, it should be given prior to the explanation of Bode's Rule.)

REINFORCEMENT

Using Bode's Rule, calculate the distance of the consecutive planets from the Sun in: (a) A.U.; (b) miles; (c) indicate difference between calculations and actual values; and (d) give a possible explanation for substantial variation between calculation and actual values.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

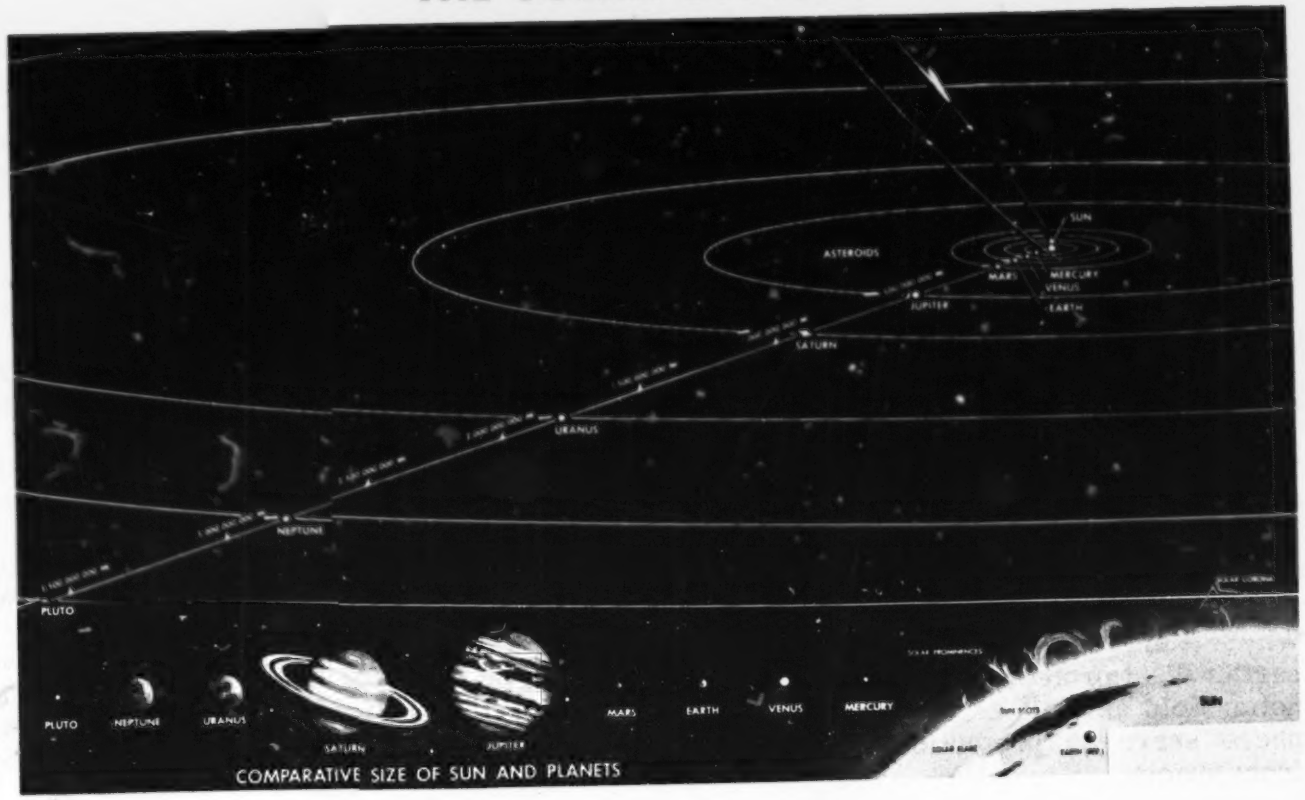
Films:

"The Solar Family," #118, black and white, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

"Time and Space Travel," Adler Planetarium, 425 E. 14th Boulevard, Chicago, Illinois.

"Measuring Time and Distance," NET 1989, National Education Television Service, Indiana University, Bloomington, Indiana.

THE SOLAR SYSTEM



TOPIC 6.09 **(10-12)**

Physics: Planetary motion

Johann Kepler (1571-1630) worked on the problem of planetary motion for more than 20 years in an attempt to reconcile theory and observation. His Three Laws of Planetary Motion deal with the speed and path of planets:

1. Planets move in elliptical paths with the Sun at one focus of the ellipse.
2. During equal time intervals, a line from a planet to the Sun sweeps out equal areas.
3. The square of the period of revolution of a planet is proportional to the cube of its mean distance to the Sun.

Of particular interest is the Third Law known as the "Harmonic Law", which may be expressed as

$$T^2 = D^3$$

with the distance in Astronomical Units and the period in Earth years. Use can be made of this Third Law in considering the relative motions of NASA's orbiting spacecrafts.

LEARNING ACTIVITIES

1. With diagrams or charts, demonstrate elliptical path of the planets with the Sun at one focus, the eccentricity of the Earth's orbit and the varying orbital speed of planets according to the Law of Areas.
2. Calculate the mean distance of Mercury to the Sun if its period of revolution is 0.241 years.
3. $T^2 = D^3$

$(241)^2 = D^3$

0.39 a.u. = D^3 = 36×10^6 miles.

4. Calculate the period of Jupiter if the distance to the Sun is 4.83×10^8 miles.
(one a.u. 92,870,000 miles or 9.3×10^7 miles)

4.83×10^8 = 5.20 a.u.

$T^2 = D^3$

$T^2 = (5.20)^3$

$T^2 = 140.61$

$T = 11.862$ years

REFERENCES and RESOURCES

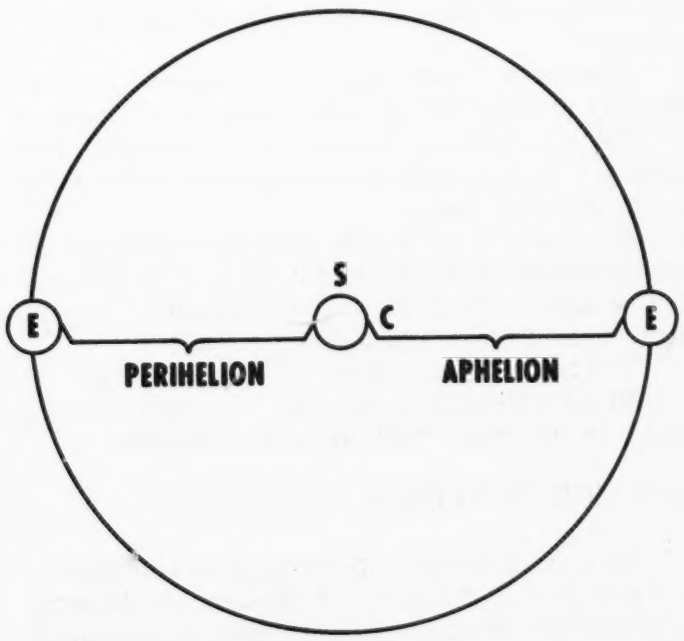
Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

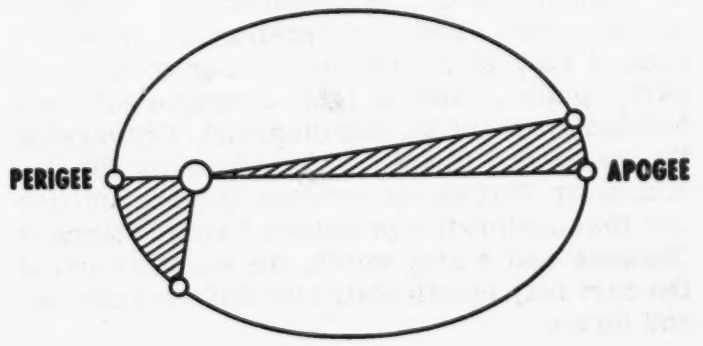
"Planets in Orbit - The Laws of Kepler." #178, black and white. Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

"The Solar Family," #118, black and white. Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

ECCENTRICITY OF EARTH'S ORBIT



VARYING ORBITAL SPEEDS OF PLANETS



TOPIC 6.10

(10-12)

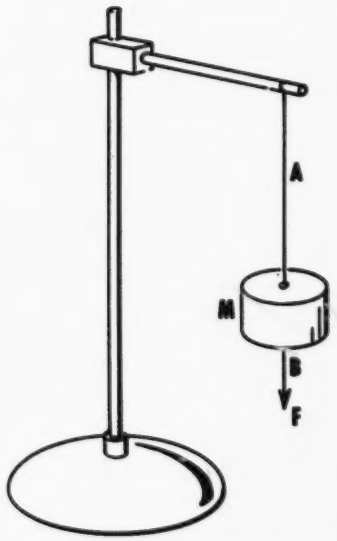
Physics: Newton's Laws of Motion

Sir Isaac Newton (1642–1727) formulated laws of mechanics which provide the basis for the study of planetary motion. When NASA launches a vehicle carrying a payload, each of Newton's Laws play an integral part and must accurately be considered to insure a successful mission.

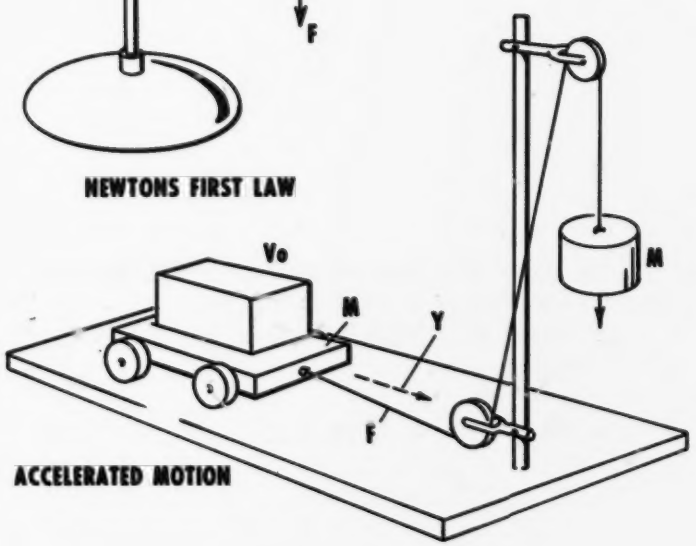
1. Newton's First Law of Motion (Law of Inertia) states: Every body continues in a state of rest or uniform motion in a straight line unless it is compelled by some external force to change that state.
2. Newton's Second Law of Motion states: The acceleration imparted to a body is proportional to the force acting on it and takes place in the same direction as the force applied.
3. Newton's Third Law of Motion (Law of Action and Reaction) states: To every action, there is an equal and opposite reaction.

LEARNING ACTIVITIES

1. Demonstrate the topics of mass and inertia in Newton's First Law of Motion by showing different breaking points for a weight suspended by a fine thread when pulled steadily and then when pulled suddenly (see diagram for Newton's Laws of Motion).
2. Demonstrate the relationship between force, mass, and acceleration in Newton's Second Law of Motion by setting up a small cart, pulley, and weight arrangement (see Newton's Law of Motion diagram). Try varying the mass and force involved to show the relationship that exists between these quantities and the acceleration produced. Using a standard distance and a stop watch, the acceleration of the cart may be calculated for different masses and forces.

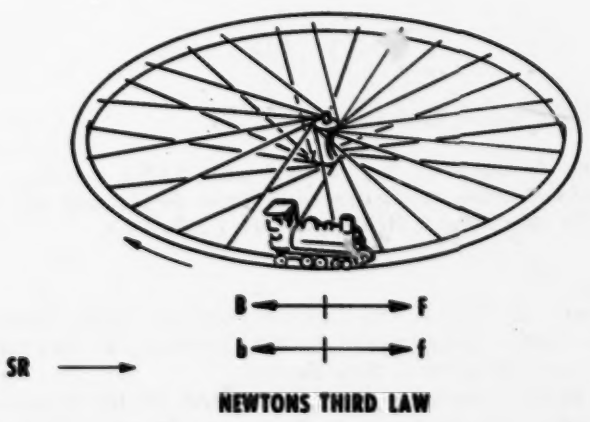


NEWTONS FIRST LAW



ACCELERATED MOTION

NEWTONS SECOND LAW



NEWTONS THIRD LAW

3. Demonstrate the action and reaction of Newton's Third Law with a toy train mounted on a circular track free to rotate. When the train moves forward, the track moves back (see diagram for Newton's Laws of Motion). Compare these motions with the situation when the track is held stationary and when the locomotive is held stationary.

REINFORCEMENT

Investigate the motion of an air puck on a smooth surface using a Polaroid camera and stroboscope to study the motion of bodies first moving with no force other than the initial force and then with a constant force. Pictures obtained show clearly the constant and accelerated motion involved by the distances between the pucks during successive exposures.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Celestial Mechanics (a booklet); Civil Air Patrol Headquarters, Ellington Air Force Base, Texas.
NF-8 Launch Vehicles
NF-20 U.S. Launch Vehicles (Color Supplement to NF-8.)

Films:
"Saturn Propulsion Systems;" 1962; NASA HQa 77, sound, color, 14 mins.
"Universe;" 1960; NASA HQa 91, black and white; 28 mins.

TOPIC 6.11

(10-12)

Physics: Gravity

Sir Isaac Newton formulated the Law of Universal Gravitation which he showed to be the consequence of his three laws of motion and Kepler's laws of planetary motion. This Law of Universal Gravitation states: Every particle of matter in the universe attracts every other particle with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them. It is this force of attraction that keeps the planets moving properly in their orbits. It is this force that keeps the moon falling towards the earth (6300 miles/day) and yet never hits it.

Mathematically, the law may be expressed:

$$F = G \frac{m\ M}{d^2}$$

where F is the force of attraction between two bodies, m and M. and d^2 is the inverse square of the distance between the two bodies. G is the constant of gravitation.

LEARNING ACTIVITIES

1. Use diagrams to demonstrate the difference between curvilinear and rectilinear motion. Show how the moon's path about the earth is the combination of linear motion and "fall" toward the earth. Show the similiarity between the "fall" of the moon and the "fall" of a pendulum bob.
2. Given the constant of gravitation as 6.670×10^{-8}, calculate the weight of the earth using the earth as one sphere and a sphere of 1 gram mass as the other body.

The attraction of the earth for a one gram mass is 980 dynes. The distance between the two objects is essentially the radius of the earth, 6.67×10^8 cm. Substituting in the mathematical expression for Newton's Law of Universal Gravitation, we have

$$F = G \frac{m\ M}{d^2}$$

$$980 = \frac{6.67 \times 10^{-8} \times 1\ \text{gram} \times \text{mass of earth}}{6.37 \times 10^8\ \text{cm}}$$

M (mass of earth) = 5.97×10^{27} grams

3. A less difficult problem than the preceding one is the investigation of the relationship between the period of a pendulum and the mass of the pendulum bob, the amplitude (arc) of its swing, and the length of the pendulum. Use various materials for the bob, different arcs, and varying lengths for the pendulum. In each case note the effect on the period as timed with a stop watch for a given number of swings. Can you express the relationship mathematically between any one of these items which varies and the period?

Calculate the value of "g" for your location by inserting data obtained in this exercise in the equation

$$t = 2\pi\sqrt{\frac{1}{g}}$$

from which you obtain the equation

$$g = \frac{4\pi^2 1}{t^2}$$

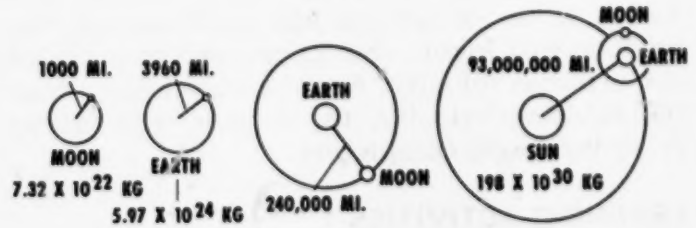
REFERENCES and RESOURCES

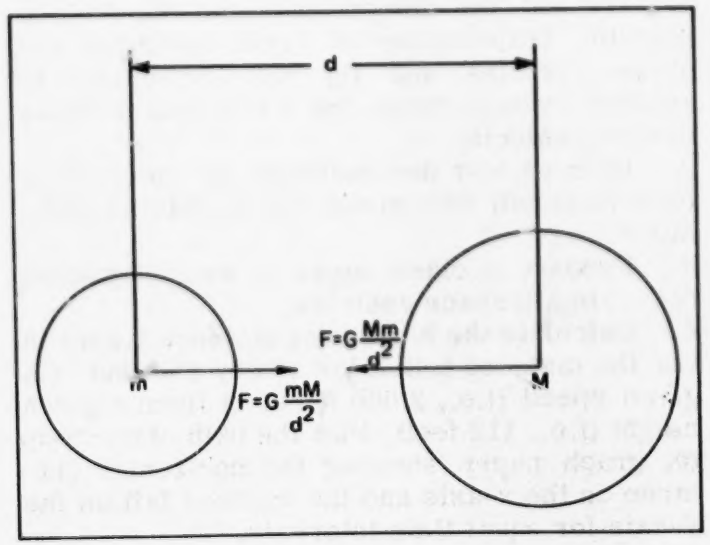
Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

"Gravity: How It Affects Us." Color, #1786, Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

"The Force of Gravity." Color or black and white. McGraw Hill, 330 West 42nd Street, New York City (text fil[illegible]).





TOPIC 6.12

(10-12)

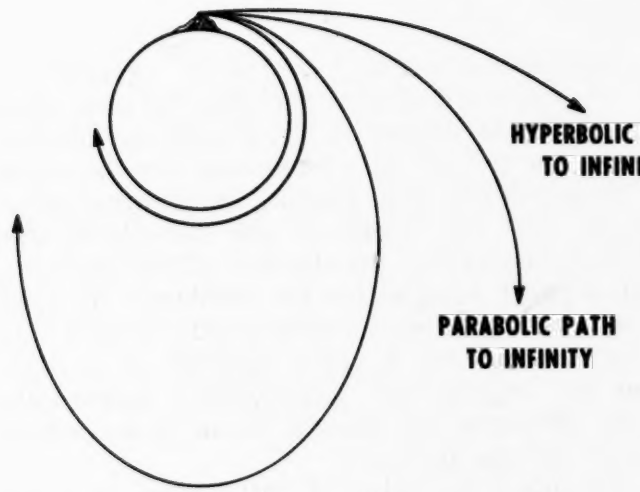
Physics: Projectiles & Satellites

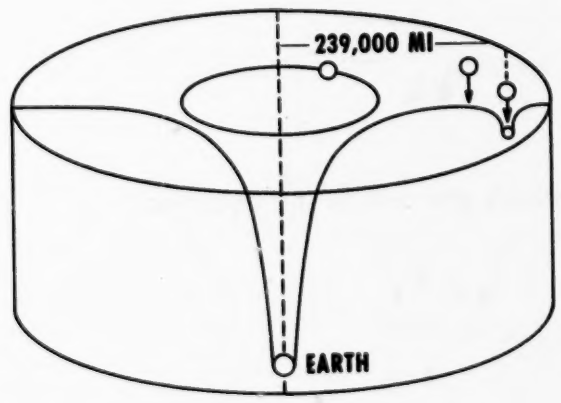
A golf ball or bullet in (horizontal) flight differs only from a freely falling body in that the former has an initial velocity imparted to it. If a projectile is shot out horizontally, the time required for it to fall to the Earth is the same as if the projectile were dropped vertically, i.e., vertical fall is not affected by horizontal motion.

Consider the situation of a space vehicle launched in a horizontal direction at a point high above the Earth. (Actually, at least two impulses are needed to put a body into a periodic orbit from the Earth: one to move the body away from the Earth and a second impulse at the proposed orbit altitude). If the initial velocity is too low, the space vehicle will follow a trajectory which will bring it back to the Earth. If the velocity is just great enough, the vehicle will circle the Earth at a rate called its orbiting velocity. At velocities higher than the orbiting velocity, the vehicle will escape from the Earth completely.

LEARNING ACTIVITIES

1. Discuss and demonstrate: (a) the various possible trajectories of Earth satellites and space vehicles and (b) velocity needed to achieve escape from the Earth and suitable orbiting velocity.
2. Discuss and demonstrate the mechanical (gravitational) well model for the Earth and the Moon.
3. Prepare a class paper on weightlessness occurring in space vehicles.
4. Calculate the horizontal distance traverse vs. the distance fallen for a body shot out at a given speed (i.e., 2,000 ft./sec.) from a given height (i.e., 112 feet). Plot the path of the body on graph paper showing the horizontal distance on the x-axis and the vertical fall on the y-axis for equal time intervals.





REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP–48).

Space Flight; NASA publication; U.S. Government Printing Office, Washington, D.C.

Voris, Frank E.; Problems of Weightlessness; Medical Aspects of Space Flight; NASA publication; U.S. Government Printing Office, Washington, D.C.

Films:

1. "Centripetal Force and Satellite Orbits." Color and black and white. Coronet Instructional Films, 65 E. South Water Street, Chicago, Illinois.
2. "Man in Space." WD-384. Color. Association Films, 347 Madison Avenue, New York City.
3. "Rockets: Principles and Safety." Color and black and white. Film Associates of California, 11014 Santa Monica Boulevard, Los Angeles, California.
4. "The Unsubstantial Flesh." NET-1367. National Education Television Film Service, Indiana University, Bloomington, Indiana.
5. "Performance of Long-Range Hypervelocity Vehicles;" 1958; NASA; sound, black and white, 30 mins.

TOPIC 6.13

(10-12)

Physics: Thrust-Rocket Propulsion

The rocket engine is based upon the principle of jet propulsion. According to Newton's third law of motion, to every action there is an equal and opposite reaction.

In jet propulsion, the stream of material escaping from the exhaust nozzle provides a reaction or thrust sending the vehicle in the direction opposite to that of the emerging gases.

However, rocket engines are different from jet engines, such as the turbojet, in that air is the oxidizer for the fuel burned in the jet engines.

Chemical rocket engines need no outside air for combustion since they carry their own fuel and oxidizer. These materials are burned in a combustion chamber and the hot gases created escape at high temperatures through a nozzle. The jet action causes a recoil of the rocket in the opposite direction.

This recoil is not the same as the single impulse created as when a gun is fired. The rocket engine recoil is spread out over the period in which the propellant burns. Since a force continually acts on the rocket during the propellant burning period, it not only reacts according to Newton's third law but also accelerates according to Newton's second law.

Thrust in rocketry is the force developed by a rocket engine which enables it to lift the vehicle against the force of gravity. Thrust is also used in obtaining fine adjustments in the velocity and trajectory of the space vehicle through use of vernier rocket engines.

The major factors which determine the amount of thrust are the rate at which propellants are burned and the velocity at which the resulting gases are expelled from the exhaust nozzle.

The chemical rocket uses a large amount of propellant and therefore limits the payload of men, instruments and equipment which can be carried.

Thrust is the product of the rate at which propellants are burned and the velocity at which the resulting gases are expelled.

Thrust = propellant flow rate x exhaust velocity.

The specific impulse is the amount of thrust derived from each pound of propellant in one second of engine operation, a measure of rocket propellant efficiency.

It can be shown mathematically that total impulse is equal to thrust times thrusting time:

Total impulse = thrust x thrusting time, from which we obtain:

Total impulse = propellant mass x exhaust velocity.

Since a certain total impulse is required for each space flight, if the exhaust velocity is low, the propellant mass must be high. The chemical rocket has a low exhaust velocity and therefore according to the previous equation requires a high propellant mass. The low exhaust velocity of chemicals is due to the fact that chemical propellants have a fixed heat of combustion releasing a limited amount of energy.

Since the chemical rocket is limited in exhaust velocity, studies have been conducted for a number of years that have shown that electrically charged particles which can be accelerated to extremely high velocities could be substituted for the particles of burned gases of chemical rockets.

However, the electrical power requirements needed to accelerate these electrically charged particles increases as the exhaust velocity increases. Convential power plants are too heavy to be used in rocket space craft. Nuclear turboelectric systems could provide the necessary lightweight power sources to drive these electric rockets.

Mass ratio is another important factor in rocket flight. The ratio is a relationship between a rocket vehicle and the propellant it can carry. It may be expressed as:

$$\text{Mass ratio} \frac{\text{total mass of vehicle at takeoff}}{\text{total mass after propellant burning}}$$

Since high mass ratio and high exhaust velocity are most important factors in determining the velocity and range of space vehicles, any improvement of the mass ratio improves the space vehicle performance. This is the reason for multistage of step rockets.

The greatest thrust is needed at takeoff to overcome the Earth's gravitational pull. After the first stage has been fired carrying the remaining stages up to terminal velocity, it may then be discarded reducing the total mass and the second stage ignited. This in turn is jettisoned and the third stage takes over. The process continues for as many stages as are in the particular vehicle, each jettisoning reducing the useless mass and improving the mass ratio.

LEARNING ACTIVITIES

1. Present rocket engine performance terminology such as thrust, thrust-to-weight ratio, specific impulse, exhaust velocity, mass ratio, etc.
2. Present diagrams and characteristics of launch vehicles used in such activities as the Mercury, Gemini, and Apollo programs.

3. Show by equations the relationship between thrust, mass of propellant and exhaust velocity for chemical rockets.
4. Discuss and diagram the various types of electric propulsion rockets.

REINFORCEMENT

1. Prepare a list of rocket propulsion terms; define and illustrate each one.
2. Prepare drawings of launch vehicles of the various NASA programs.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

"Before Saturn;" 1962; NASA HQa-76; sound, color, 14 1/2 mins.

"Father of the Space Age," 1961; NASA HQa-54; sound, black and white, 18 1/2 mins.

"Man and the Moon," Walt Disney Productions, Educational Film Division, 500 So. Buena Vista Street, Burbank, California.

"Reaction and Momentum;" NET-290; National Educational Television Film Service, Indiana University, Bloomington, Indiana.

"Satellites and Missiles;" NET-1368; National Educational Television Film Service, Indiana University, Bloomington, Indiana.

"Steps to Saturn;" 1962; NASA HQa-67; sound, color, 22 mins.

"Turbojets, Pulse Jets, and Ramjets;" NET-294; National Educational Television Film Service; Indiana University, Bloomington, Indiana.

TOPIC 6.14

(10-12)

Physics: Space Communications

Radio waves travel in straight lines which would ordinarily limit the distance of transmission due to the curvature of the earth. Yet we are able to broadcast over long distances due to "bouncing" the waves off the ionized layer of our atmosphere called the ionosphere. The ionosphere is subject to disruption particularly from solar flares and causes problems in high frequency radio communication.

Microwaves are extremely high frequency waves used for long distance communication but require the use of repeater stations which receive and transmit the communication since microwaves travel in straight lines and are not reflected by the ionosphere. Microwave repeaters spaced about 30 to 50 miles apart (line of sight) can thus transmit over the curvature of the earth. Microwave transmission has the capability of handling much more communication in addition to television transmission than either cable or ordinary radio transmission.

Since repeater stations cannot be easily placed in oceans, communication satellites can provide the necessary repeater height to enable messages to be transmitted across vast distances without the use of conventional cables. The Relay and Syncom Satellites are examples.

Two types of communication satellites are the passive satellite and the active satellite. The passive satellite reflects a transmitted signal from one point on the earth to another point. The active satellite has a radio receiver which receives the signal and a transmitter which transmits the amplified signal back to earth. While passive transmitters require sensitive ground receivers and powerful transmitters, they do not have any electronic components that can fail.

The Echo and West Ford systems are examples of passive systems using in one case a large reflective sphere and in the second case, orbiting dipoles which reflect the signal back to the earth. Active satellite systems may either store and forward information at appropriate intervals or may be of the line-of-sight type where a communication satellite is of such a height that its signal can be transmitted and received by ground stations thousands of miles apart.

Solar cells are used to power satellites since Solar energy is the naturally occurring source of energy available in space. During periods of darkness, nickel-cadmium storage cells may be used.

The 100 foot diameter satellite Echo I and the 135 foot diameter Echo II are perhaps the best known of the passive type communication satellites whereas Telestar and Syncom are the best known of the active types. Score, Courier, Relay, and Oscar are other active satellite systems sponsored by different private and public agencies. In general, active satellites are superior to passive systems.

LEARNING ACTIVITIES

1. Present the various types of active and passive communication satellites showing method of communication, advantages and disadvantages.

2. Investigate the possibility of transmitting space data and other communications on laser beam frequencies.
3. Write a paper on the Communication Satellite Act (ComSat Act (P.L. 87-624) and the Early Bird satellite.
4. Discuss the possibility of nuclear reactors such as SNAP (Systems for Nuclear Auxiliary Power) to power satellite communication systems.

REINFORCEMENT

1. Give a talk on the solar cell, its principle and uses.
2. Explain the TELESTAR system of TV transmission.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:
"Echo In Space," NASA Film Service.
"Radio Waves," McGraw-Hill Text-Films, 330 W. 42nd St., New York, N.Y.
"The Big Bounce," Bell Telephone Co., local address.
"Telestar," Bell Telephone Co.

TOPIC 6.15

(10-12)

Physics: Radiation and Magnetism

NASA scientists are doing extensive basic research with terrestrial and extraterrestrial radiation. When we use the term radiation, we refer to energy impulses which range from gamma rays to long radio waves. Included also are X-rays, ultraviolet, visible light, infrared, short waves, TV and ordinary (standard broadcast) waves. These various rays and waves make up what is called the electromagnetic spectrum. They all travel at the speed of light but have different wave lengths and rates of vibration or frequency.

Radioactive materials give off radiation, namely alpha, and beta particles and gamma rays. Only the gamma rays are considered in the radiation with which we are concerned.

Electromagnetic radiation consists of interrelated electrical and magnetic waves which travel through space. Through the concept of a combination of electrical and magnetic waves, James Maxwell a nineteenth century physicist was able to give a theoretical model for light, one of the forms of electromagnetic radiation.

Gamma rays and X-rays are absorbed before reaching the earth. A small amount of ultraviolet rays penetrate to the earth. Solar radiation which includes ultra violet, visible light and infrared rays supplies directly or indirectly all the energy of our earth.

Since electromagnetic radiation transmits through space, it may be sensed by satellites as they travel in their various journeys. Tiros and Nimbus satellites use radiation sensors to obtain meteorological data and cloud pictures useful in weather prediction.

Magnetism as we commonly use the term refers to the ability of certain substances to attract iron or steel. Iron, steel, and certain alloys make magnets of a temporary and permanent nature. The earth itself acts as a giant magnet with north and south magnetic poles.

The interrelationship of radiation and magnetism has already been mentioned in Maxwell's explanation of the wave nature of light.

Flights of Explorer II showed further relationship between magnetism and radiation. A belt of intense radiation formed from charged particles of high energy shot out by the sun during solar flares was trapped by the earth's magnetic field and was named the Van Allen radiation belt after J.S. Van Allen well known in early satellite flights. While once it was believed that there were two belts (inner and outer), now it is felt that only one great radiation belt exists beginning about 500 miles above the equator and extending 40,000 miles.

Our atmosphere protects us on the earth from most radiation considered to be harmful. Protection for the astronaut in space from the various kinds of radiation including cosmic rays which have the greatest energy of all rays is one of the chief concerns in manned flights.

LEARNING ACTIVITIES

1. Discuss and demonstrate types of radiation by means of an electromagnetic diagram and show the location of the Van Allen belt around the earth.
2. Discuss various means of protecting astronauts from radiation hazards both thermal, visible and invisible.
3. Write a paper on the nature of the Van Allen belt.

REINFORCEMENT

1. Look up references concerning the earth's magnetism and prepare a talk on the shifting of magnetic direction through the ages as evidenced by geological studies.
2. Compare the molecular and domain theory of magnetism.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:
"Cosmic Rays," McGraw-Hill Text-Films, 330 W. 42nd St., New York, N.Y.
"Magnetic Force," McGraw-Hill Text-Films.
"Research by Rockets," McGraw-Hill Text-Films.
"Atomic Barrage," National Education Television Film Service, Indiana University, Bloomington, Indiana.

TOPIC 6.16

(10-12)

Chemistry: Ablation, Re-entry Heating

We are all familiar with ordinary burning or oxidation in which oxygen unites with a combustible material at a certain temperature producing light and heat. Some less well-known forms of burning include the uniting of chlorine with antimony and sulfur with iron (familiar to all chemistry students!).

The heating of the surface of spacecraft due to air friction during re-entry is a far greater problem than can be solved by ordinary means. For example, supersonic aircraft flying at 2,000 mph generate a "skin" temperature of 650° F. Titanium alloys which have a melting point of 3,000°F seem to offer a good solution for material to build the plane's exterior.

However, re-entry temperatures of 3,000°F were common for Mercury spacecraft. On return trips from the Moon, the temperature will be even greater. Thus, high melting point temperature materials will not be adequate for such spacecraft.

A successful method of protecting astronauts from the extreme temperatures resulting from air friction is to protect the re-entry capsule with a heat shield which contains material that absorbs heat by first melting, then vaporizing, and finally separating of the melted or vaporize material from the shield(ablation). The absorption of the heat by the material resulting in a change of state and final separation prevents heat transfer to the capsule by conduction.

One form of heat shield is made from ablative materials, consisting of phenolic compounds (phenolic epoxy resins, phenolic asbestos) in a "layer cake" construction encased in a high melting point metal such as beryllium. In addition to these plastic materials, ceramic materials (usually quartz) may be used.

LEARNING ACTIVITIES

1. Present diagram of re-entry capsule and discuss re-entry speeds, angles, and temperatures.
2. Discuss nature of ablation (heat loss due to change of state and separation of material) as contrasted to various types of burning.

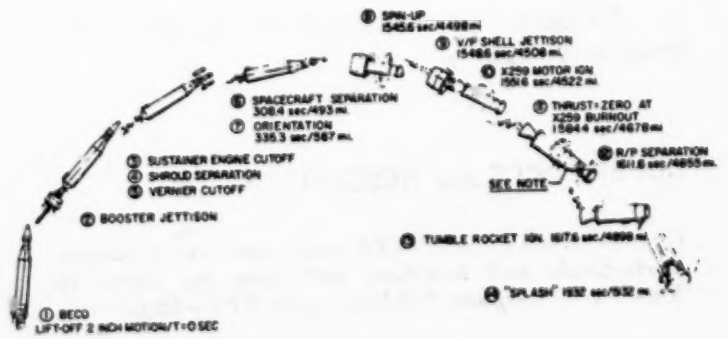
REINFORCEMENT

Write a paper for class presentation on ablative materials and ablation. Construct charts of heat shields for re-entry capsules. Prepare a demonstration of various types of burning. Demonstrate and explain methods of heat transfer. Discuss geometric shapes for spacecrafts.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:
"A Torrid Journey," NET-1363, National Educational Television Film Service, Indiana University, Bloomington, Indiana.
"Beating the Heat;" 1958; NASA HQ1, sound, color, 18 1/2 mins.
"Chemistry of Meteor Vaporization;" 1960; NASA HQ-6, sound, color, 27 1/2 mins.
"High Temperature Materials;" 1958; NASA HQ-4; sound, color, 27 mins.
"Returning from the Moon;" 1966; NASA, sound, black and white, 28:21 mins.



FIRE Vehicle Trajectory and Flight Sequence of Events

TOPIC 6.17

(10-12)

Chemistry: Nuclear Reactions and the Sun

NASA has several basic research programs and satellites designed to help us better understand our sun and its influence and effects on interplanetary space. These programs include the Interplanetary Monitoring Platform (IMP) satellites which study the cislunar radiation environment over significant solar cycles. They are also helping in the development of solar-flare prediction ability which will permit NASA to determine radiation hazards for Apollo support. Another interesting study is the one supported by the Orbiting Solar Observatory (OSO). Its mission is to obtain data which will enable NASA and the investigating scientists to map the solar disc in ultraviolet and X-ray. The corona will be mapped in white light. The ultraviolet and gamma rays of the celestial sphere will also be mapped. At the same time the Orbiting Geophysical Observatory (OGO) is collecting data on the galactic and solar radiation in the Earth's atmosphere. Several other areas of investigation can be carried out by the use of the OSO and the OGO satellites, since they are standardized spacecraft. This standardization permits a great variety of experiments to be flown on the basic (one design) spacecraft.

The chemical reactions which take place in the Sun are not the ordinary chemical reactions we deal with daily on the Earth.

Ordinary chemical reactions involve only the valence electrons in the outermost shells of atoms. The energy released or absorbed by these reactions is of a limited amount. No change occurs in the nucleus of the atom and the amount of matter remains the same before and after the reaction.

Nuclear reactions, on the other hand, release tremendous amounts of energy, far beyond that of ordinary chemical reactions. The nucleus is affected in these changes with a conversion of some matter into energy.

Two kinds of nuclear reaction are:

a. fission - a heavy nucleus splits into lighter nuclei
b. fusion - lighter nuclei combine to form a heavier nucleus.

Fusion or thermonuclear reaction appears to be the source of the Sun's energy. In this reaction, hydrogen is converted into helium with a loss of mass. The output of energy is immense, i.e., of the order of 5×10^{23} horsepower. In this process, 564 million tons of hydrogen are converted into 560 million tons of helium with annihilation of four million tons of matter every second.

Hans Bethe, in 1938, suggested a series of reactions that might explain the nuclear reaction in the Sun. The net result of these reactions was that from four hydrogen nuclei, helium and positrons are produced with the liberation of 30 million electron volts of energy. A number of other possibilities of hydrogen-helium conversions exist involving heavier hydrogen isotopes.

It has been estimated that the Sun's reaction has been going on for about four to five billion years and will continue for another five billion years. Although the conversion of all the Sun's hydrogen into helium will involve only one per cent decrease in the Sun's mass, the life of the Sun will undoubtedly be over when this conversion has taken place.

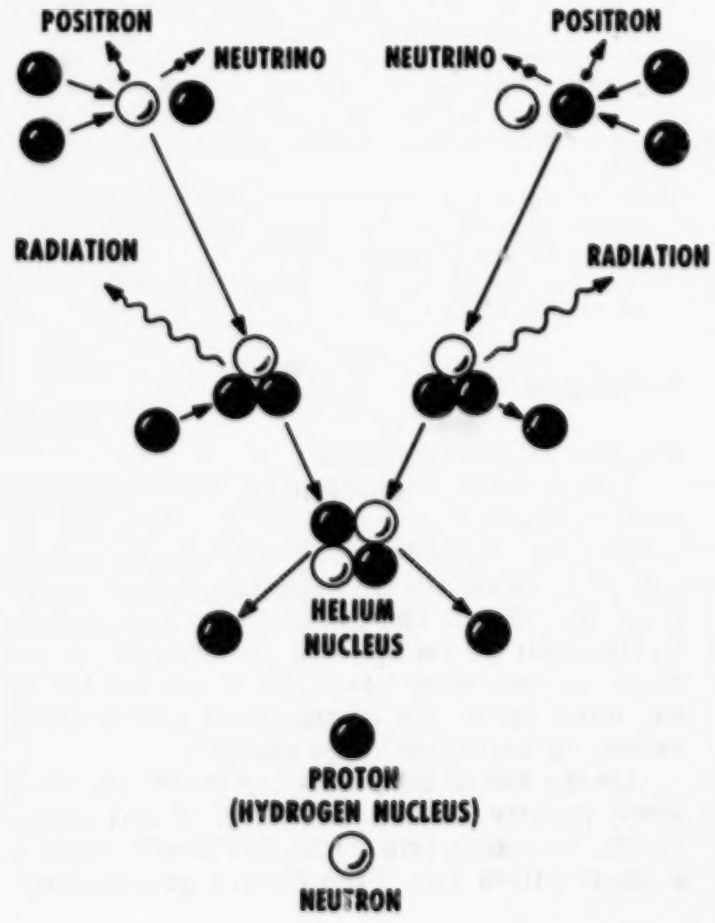
In order for this reaction to take place, the center of the Sun has a temperature of about 28,000,000°F. At this temperature, atoms are stripped of their electrons and nuclear reactions occur between nuclei.

LEARNING ACTIVITIES

1. Discuss and give the main types of nuclear reaction with equations.
2. Show several types of fusion reactions involving conversion of heavier hydrogen nuclei into helium.
3. Explain the nature of plasma in nuclear reactions.
4. Discuss the control of thermonuclear reactions by such devices as the stellator and magnetic mirror or bottle.

REINFORCEMENT

1. Look up Hans Bethe's series of reactions explaining the Sun's nuclear reactions.
2. Compare the atom bomb (fission) with the hydrogen bomb (fusion).
3. Present a paper on the solar cell, its construction, and future possibilities.
4. The fuel cell is a very promising source of auxiliary power for spacecraft. Present a



chalk board discussion on how it works and the chemical reactions.

5. Present a paper on the amount of energy released by the Sun, the amount reaching the Earth, and the possible ways of more efficient utilization of this energy.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NF-13 Orbiting Geophysical Observatory.
NF-29 Orbiting Solar Observatory.

Films:

"Orbiting Solar Observatory." 1962; NASA HQa 95, sound, color, 26 mins.

"The Mystery of the Sun." black and white, Adler Planetarium, 425 E. 14 Blvd., Chicago, Illinois.

"The Sun." NET-1958. National Educational Television Film Service, Indiana University, Bloomington, Indiana.

"The Sun and How It Affects Us." Color and black and white; Coronet Instructional Films, 65 E. South Water Street, Chicago, Illinois.

"Power for the Moonship." 1966; NASA sound, black and white, 28:23 mins.

TOPIC 6.18

(10-12)

Chemistry: Rocket Fuels

Man lives in a gravitational field which has been compared to a well or pit thousands of miles deep. NASA has developed several launch vehicles which can lift specific payloads away from the Earth. The payload may then go into Earth orbit or be sent on its mission to the Moon or into deep space. To reach the Moon, we must climb out of this well onto a plane called "gravitational free space".

On the Moon, the "well" is much less deep since gravity is only one-sixth of that on the Earth. A return trip to the Earth will require a short climb out of the Moon's gravitational field and entrance into the Earth's gravitational field. This latter (entrance into the Earth's gravitational field) has been compared to sliding down a steep hill as if there were sides to our gravitational "pit".

As we have already seen, rockets move in an action-reaction manner described by Newton's Third Law of Motion and accelerate during the propellant-burning period according to Newton's Second Law of Motion.

Various fuels have been employed or considered as a means of propelling rockets or spacecraft. Two main classes of fuels are liquid and solid propellants.

The liquid propellant may be either a bi-propellant, using two different liquids such as kerosene or liquid hydrogen as a fuel and nitric acid or liquid oxygen as an oxidizer, or a mono-propellant in which a single fuel decomposes to provide the jet action. Hydrogen peroxide is an example of a well known mono-propellant.

Solid rocket propellants are composed of a fuel and an oxidizer mixed together and forming a powder or rubber-like material known as the "grain" or "charge".

Liquid propellants include alcohol, liquid hydrogen, kerosene, and aviation gasoline as fuels and liquid oxygen, nitric acid and fluorine as oxidizers. Solid propellants are asphalts, waxes, oils, plastics, metals, rubbers, and resins mixed with nitrates and perchlorates as oxidizers.

In liquid propellant rockets, the propellants are stored in tanks and fed into the combustion chamber by means of high speed pumps or the force of a high pressure gas. The solid propellant rocket has the grain packed in the rocket casing which acts as a storage and combustion chamber.

A general statement of the equation for rocket propellant combustion may be stated as follows:

Oxidizer + Fuel ⟶ Gaseous Combustion Products + Energy

For example:

$H_2 + F_2 \longrightarrow HF + H_2 + F_2 + F + H + \text{Energy}$

Energy

We note that there are five different gaseous reaction products which can be formed:

$H_2 + O_2 \longrightarrow H_2O + H_2 + O_2 + H + O$

OH + Energy

In this case, we note that there are six different gaseous reaction products.

The burning of liquid propellants is easier to control than that of solid mixtures. By simply regulating a valve, liquid propellant combustion may be stopped. Solid propellant combustion is much more difficult to stop.

Solid fuel has the advantage of simplicity since it requires no tanks, injectors, pumps, plumbing, and cooling systems. It is convenient to store and handle. Lower performance and difficulty of control, sensitivity to temperature variations, and limited firing time variations are disadvantages of solid fuels.

Liquid fuels give a longer firing time, greater energy and can be somewhat easily controlled. However, they cannot always be stored in the launch vehicle and, as previously indicated, require complex fuel systems.

NASA is doing a large amount of research on nuclear and ion powered rockets which also offer great possibilities from the standpoint of long-distance space flight. Nuclear rockets depend upon the heating of fuels to temperatures of the order of 4,000°F and then expelling the heated gases from the rocket nozzle. The fuel may be liquid hydrogen, helium or ammonia. No change takes place in the working fluid, except dissociation. The nuclear reaction might be fission or fusion as a source of energy to heat the fuel. The fusion reaction offers great control problems in terms of containing the heated gases involved in the reaction within a suitable container, probably a magnetic field. The great

advantage of the nuclear engine is the tremendous quantities of energy available from a small amount of nuclear fuel.

Ion rocket engines are based on the electrical acceleration of charged particles producing thrust. Cesium is a common fuel because of the ease with which it can be ionized. When cesium is heated, the resulting ions are accelerated to high velocities by an electric field and then ejected from the rocket nozzle. The thrust of ion rocket engines is low and would have to be used with chemical or other type of powered rockets in the initial stages. The great advantage of the ion rocket is that it can provide great exhaust velocities in interplanetary travel with a minimum of fuel.

LEARNING ACTIVITIES

1. Review, and repeat if possible, action - reaction and acceleration demonstrations suggested in Newton's Laws of Motion unit.
2. Present momentum concept and the conservation of linear and angular momentum by simple demonstrations, such as head-on collision of spheres and variable spinning action of a student standing on a turntable.
3. Present charts showing main types of liquid and solid propellants, their characteristics and types of rocket engines.

REINFORCEMENT

1. Investigate and report on various types of rocket engines.
2. Review and repeat air puck demonstrations suggested in Newton's Laws of Motion unit.
3. Present simple jet demonstrations of motion of a balloon from which air is escaping and action of water sprinkler with water flowing through it.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NF-8 Launch Vehicles
NF-20 U.S. Launch Vehicles (Color Supplement to NF-8)

Propulsion for Deep Space, NASA, Lewis Research Center, Cleveland, Ohio, June 1966.

Films:

"Electric Propulsion." 1965; NASA sound, color, 24 mins., (Also available in 35mm color film strip with script.)

"Missiles, Rockets and Satellites." (Next 100 Years Series). 1959; NASA HQa14; sound, black and white, kinescope, 28 1/2 mins.

"Rockets: How They Work." Color and black and white, #1685. Educational Testing Service, 20 Nassau Street, Princeton, New Jersey.

(See also "Suggested Films" under Thrust-Rocket Propulsion unit.)

TOPIC 6.19

(10-12)

Chemistry: Spectroscopy

Until the advent of space probes by rockets and flights of manned and unmanned satellites, most if not all the information concerning the chemistry of celestial bodies came to us by analysis of the light from these distant bodies. Meteorites were the only source of solid material that was available for ordinary chemical analysis. In the not too distant future, we should be able to obtain actual samples from the moon's surface. In the meantime, space probes by unmanned satellites such as the Mariner and Ranger spacecraft and Surveyor and Lunar Orbiters supply us with data in many fields which directly or indirectly add to our knowledge of the chemical nature of the planets and our moon.

For the more distant stars, spectrum analysis will continue to be our only source of information as to the chemical nature of these celestial objects.

When substances are heated to a high temperature they give off light. The band of light produced is called a spectrum. The spectrum of white light produced by an incandescent solid is a continuous band of color shading from red through orange, yellow, green, blue, and indigo to violet. The spectrum of light from incandescent gases like those of lithium, sodium and potassium flames is a series of bright lines. These differ in color and position for each element and serve to identify the element. For example, if a sodium compound is heated in a flame, the resulting sodium flame shows two yellow lines very close together when viewed with a good spectroscope. Light from an incandescent solid which passes through a cool vapor of the same element will show dark or Fraunhofer lines where the characteristic lines were absorbed. Certain lines in the spectrum of the sun revealed the presence of helium before it was discovered on the earth.

Lines of the spectrum not only reveal the various chemical elements but from the nature of the element as an atom, ion, or molecule we can determine the temperature of the material since the state of the element depends on its temperature.

LEARNING ACTIVITIES

1. Demonstrate the nature and construction of a spectroscope using simple flame tests.
2. Conduct flame tests for lithium, sodium, potassium, calcium, strontium, barium and copper.
3. Write a paper on the diffraction grating and prism as optical devices producing a spectrum.

REINFORCEMENT

1. Discuss the use of spectrum analysis to study motion of heavenly bodies through spectrum shift.
2. Explain the manner in which light is released during flame tests on the basis of movement of electrons from one energy level to another.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Films:

"Finger Prints of the Stars," National Educational Television Film Service, Indiana University, Bloomington, Indiana.

"Unmanned Spacecraft" - 1961, NASA HQ38, sound, color, 14 1/2 mins.

TOPIC 6.20

(10-12)

Chemistry: Atmospheric Composition

One phase of man's environment on planet Earth is comparable to that of fish living at the bottom of an ocean. However, our ocean is a physical mixture of gases rather than a liquid. Probes of upper space made by the NASA Explorer series have been most helpful in measuring density, radiation, and temperature of the atmosphere.

The gases near the earth are mainly the elements and compounds by volume, nitrogen 78 per cent, oxygen 21 per cent, argon 0.9 per cent, carbon dioxide 0.03 per cent and traces of neon, helium, krypton, xenon, free hydrogen, methane and nitrous oxide.

In addition, at lower levels there is water vapor and depending on location, such items as particles of dust, fumes, pollen and salt. Approximately 50 per cent of the gases that constitute the atmosphere are within 3 miles of the earth. Recent studies have changed the extent of the outer limits of the atmosphere. As a result of research started in the International Geophysical Year in 1957, the previous designation of the layers of the atmosphere into troposphere, stratosphere, ionosphere and exosphere have been revised. Two main layers have been suggested by Marcel Nicolet of the National Space Research Center, Brussels, Belgium. These layers are a homosphere of about 55 miles in depth and a heterosphere of approximately 22,000 miles.

The homosphere corresponds roughly to the former troposphere and stratosphere and is characterized by a uniformity in chemical composition as to the ratio of nitrogen to oxygen, etc. The homosphere is divided into the following subregions: a troposphere extending to about 8 miles with a temperature range of 59°F at sea level to -70°F at the outer limit; a stratosphere extending out 30 miles from the earth's surface with temperatures ranging from -70°F to -45°F for approximately one half the region and then rising to a maximum of 30°F; and finally, a mesosphere extending out to 55 miles from the earth with temperatures as low as -130°F at the outer edge. Transition zones are recognized between each layer.

The heterosphere is divided into subregions characterized by a particular chemical element. From 55 miles to 125 miles out from the earth there is a nitrogen or a nitrogen-oxygen layer; from 125 miles to 700 miles out there is an oxygen layer; from 700 miles to 2,200 miles there is a helium layer; and from 2,200 miles outward to 22,000 miles, hydrogen is the dominant element.

LEARNING ACTIVITIES

1. Present charts or diagrams showing earlier and present concepts of the atmosphere.
2. Construct a chart comparing the structure of the earlier concept of the atmosphere with the present concept.
3. List the elements and compounds present in the latest concept of the earth's atmosphere.

REINFORCEMENT

Write a paper on the temperature and density variations in the different layers of the atmosphere emphasizing the role of the NASA Explorer series and influence of solar activity (sun spots, solar flares, etc.) on these variations.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Explorer XIX, The Air Density Satellite, NASA Facts, NASA Educational Publications Distribution Center, AFEE-1, Washington, D.C., 20546.

Films:

"Mirror in the Sky," Academy Films, 1145 N. Los Palmas Ave., Hollywood, California.

"Studies of the Upper Atmosphere," National Educational Television Film Service, Indiana University, Bloomington, Ind.

"The Sea of Air," National Educational Television Film Service.

"Tiros I and Tiros II Experimental Weather Satellites," NASA Film Service, (local address).

7. Mathematics

by Project Staff

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Mathematics

TOPIC 7.01

Numbers and Counting

LEARNING ACTIVITIES

(K-3)

1. When developing ideas about numbers through one-to-one correspondence, or grouping into sets, include pictures and names of space-related things.
2. Use launch countdowns when drilling with counting numbers.

REINFORCEMENT

1. Comparing various groups of the same number leads to the development of the concept of number as an abstraction. Combining groups, or breaking groups into parts, leads to ideas about addition and subtraction.

Instead of using such common objects as sticks, balls, or rabbits, use groups (sets) of satellites, astronauts, or simple drawings of rockets or launch vehicles. The end result of this activity is the development of the usual understandings of number, with additional interest and information resulting from the use of the more exciting objects of the Space Age.

2. Counting backwards, as in launch countdowns, is an excellent device for drilling students in the sequence of numbers.

TOPIC 7.02

The calendar

LEARNING ACTIVITIES

(K-3)

1. Have the students locate on the calendar the series of dates for a space event, such as a launch.

REINFORCEMENT

1. The Gemini-Titan II Launch Vehicle, used for placing all of the Gemini spacecraft into orbit, was manufactured by the Martin Company as prime contractor. Certain parts were manufactured by sub-contractors.

Below is a condensed schedule of the events involved in the building and assembly of the vehicle used to launch Gemini 5.

January 1963 - Welding of fuel tanks begun by Martin Division in Denver
April - May, 1964 - Fuel tanks tested and inspected
June 25, 1964 - Tanks received by Martin Division in Baltimore
October 15, 1964 - Tanks retested
December 2 - 5, 1964 - Assembly of tanks and other launch vehicle components
November 5 - December 9, 1964 - Engines received from subcontractor
January 7, 1965 - Engines tested in horizontal position
January 15 - 29, 1965 - Launch vehicle painted and tested
March 8, 1965 - Launch vehicle tested in vertical position
April 26 - 30, 1965 - Inspection by quality control experts
May 10 - 12, 1965 - Final tests
May 15, 1965 - First stage taken by airplane to Cape Kennedy
May 18, 1965 - Second stage taken by airplane to Cape Kennedy
June 7, 1965 - Vehicle assembled on Launch Complex 19
June 29, 1965 - Complete test of vehicle systems
July 5, 1965 - Gemini placed on top of vehicle
July 22, 1965 - Simulated launch to test all systems
August 12, 1965 - Simulated flight test
August 21, 1965 - Gemini 5 launched after flawless countdown

a. Have students locate some or all of the above dates on the calendar.
b. Have students count the number of days, months, or years which elapsed between the various steps in assembling the launch vehicle. For example, how many months passed between the time when the welding of the tanks began and the launch? How many days before the launch was the first complete test of vehicle systems made? How long was the Gemini spacecraft on the top of the launch vehicle before the launch took place?
c. Only the major tests of the equipment are mentioned in the above schedule. How many such tests were there?

TOPIC 7.03

Time

LEARNING ACTIVITIES

(K-3)

1. Have students locate on the clock the times for the events in a manned launch.

REINFORCEMENT

1. An abbreviated schedule of the launch countdown is often given by the major newspapers and news magazines when they print stories of manned space flights. Many students will enjoy locating the times on the clock and counting the number of minutes between countdown intervals. The following gives a somewhat detailed countdown for the Gemini 5 flight by astronauts Gordon Cooper and Charles Conrad. T is the time when liftoff took place.

T-2 days	Medical examination of flight crew
T-1 day	Preparations for launch countdown
T-270 minutes	Awaken crew
T-225 minutes	Complete certain safety tests
T-220 minutes	Crew has breakfast
T-180 minutes	Crew leaves for spacecraft
T-170 minutes	Crew arrives at spacecraft. Sensors for measuring heartbeat, breathing, and the like placed of crew members.
	Crew puts on space suits.
T-115 minutes	Final tests. Verify launch vehicle "GO" for flight
T-109 minutes	Crew leaves ready room
T-100 minutes	Crew enters spacecraft
T-34 minutes	Start lowering erector
T-30 minutes	Activitate spacecraft communication system
T-23 minutes	Spacecraft switched to internal power
T-6 minutes	Final check
T-5 minutes	Start telemetry (measurement) recorders
T-2 1/2 minutes	All personnel clear area
T-0 minutes	Engines start. Spacecraft lifts off.

a. Have students locate some or all of the above times on the clock. (Liftoff was on August 21, 1965 at 9:00 a.m. Eastern Standard Time.)

b. Have students compute, or count, some time intervals. For example, how long before liftoff was the crew awakened? How soon after they were awakened did they have breakfast? How long before liftoff were support personnel notified to leave the area?

TOPIC 7.04

Comparison

LEARNING ACTIVITIES

(K-3)

1. Develop ideas of large, small, more than, and less than by using space-related objects.

REINFORCEMENT

1. Compare the heights of launch vehicles with each other and with common objects.

Object	Height or length
Saturn V	364 ft.
Football field	300 ft.
Saturn I	225 ft.
Delta	90 ft.
Gemini-Titan II	109 ft.
Side of baseball diamond	90 ft.
Scout	72 ft.

Discussion of the above data, aided by pictures or drawings, should enable students to understand that among the present NASA launch vehicles, Saturn V is "large," the Scout is "small," Saturn V is larger than Saturn I or Delta, and the like.

A similar comparison could be made by using the diameters of bodies in the solar system. If the earth is taken as the standard of size, they compare approximately as follows:

Body	Diameter, if earth = 1
Earth	1
Moon	1/4
Sun	108
Mars	1/2
Venus	1
Mercury	1/3

TOPIC 7.05

Measures of weight and volume

LEARNING ACTIVITIES

(K-3)

Have students compare weights and volumes of space vehicles with those of common objects.

REINFORCEMENT

Students can compare some typical weights with weights of certain space vehicles. Since most space vehicles or hardware, especially those with which the pupils are acquainted, are quite heavy, it may be well to use a rather large unit of weight such as the ton. To relate the ton to their own experience, it might be pointed out that a gallon of water weights 8 1/3 pounds, so that 240 gallons weigh one ton. In the following table, most weights are given in both tons and

pounds. Students may use either unit, whichever suits their level of mathematical maturity.

To help students understand the increasing size in weight and volume of manned spacecraft, explain that the vehicles in the tables represent three series of space vehicles. The first series was the Mercury program, in which the space capsule held only one man. The second series was the Gemini program, now completed, in which the space capsule held two men. The third series, now under development, is the Apollo program, one of the purposes of which is to land men on the moon. Note that the Apollo configuration which is to be sent to the moon contains four parts, and that the total weight of this configuration is 95,000 pounds. Show pictures of the three series of spacecraft, and explain briefly the series of events in the trip to the moon. (The Adapter Section will be removed and jetissoned on the way to the moon, exposing the Lunar Module. This module will descend to the moon, leaving the Command Module and Service Module in lunar orbit. The astronauts will take off from the moon in the upper part of the Lunar Module and will join with the Command and Service Modules. The Lunar Module will then be discarded, and the Service Module will provide the push to start the Command Module back to earth. On the way to earth the Service Module will be discarded, and only the Command Module carrying the three astronauts will return to earth.)

Object	Weight (pounds)	Weight (tons)
240 gallons of water	2,000	1
Manned Mercury spacecraft (one man)	3,000	1 1/2
Large luxury automobile	5,000	2 1/2
Manned Gemini spacecraft (two men)	8,500	4 1/4
Apollo spacecraft Command Module (three men)	11,000	5 1/2
Apollo spacecraft Service Module	50,000	25
Apollo spacecraft Lunar Module (two men)	30,000	15
Apollo spacecraft Adapter Section	4,000	2
Medium-size automobile	3,000	1 1/2

a. Have students arrange the above objects in order according to weight.
b. Have pupils find out how much more one object weighs than another.
c. Have pupils compare the objects according to weight, indicating which is heaviest, which is lightest, which weight is greater than another, which is less than another, and the like.

Students should also compare some typical volumes with the volumes of well known space vehicles. It might be well if the teacher or a pupil constructs a model or two to help the pupils gain an appreciation of the volume occupied by one cubic foot. For example, a cube one foot on each edge contains just one cubic foot. A cube three feet (one yard) on each edge contains 27 cubic feet. Finding the volume of an average living room, the classroom, a clothes closet, and estimating the volume in a medium-size automobile will help the students understand the concept of volume.

Object	Volume of interior (cubic feet)
Cube, one foot on each edge	1
Cube, one yard on each edge	27
Apollo spacecraft Command Module (three men)	366
Apollo spacecraft Lunar Module (two men)	245
Average living room (16 ft. x 14 ft. x 9 ft.)	2000
Your classroom	?
Gemini spacecraft (two men)	101
Mercury spacecraft (one man)	65

a. Have students arrange the above objects in order according to size (volume).
b. Have pupils find out how much larger one object is than another.
c. Have pupils compare the objects according to volume, indicating which is largest, which is smallest, which volume is greater than another, which is less than another, and the like.
d. Have students note the increasing size of manned spacecraft as the space program has developed and as the spacecraft have been built to place larger numbers of men into orbit.

TOPIC 7.06

Measurement of temperature

LEARNING ACTIVITIES

(4-6)

1. Use high and low space-related temperatures to illustrate positive and negative numbers.

REINFORCEMENT

1. Space exploration has required that we learn how to handle materials at very high and low temperatures. The best propellant fuel, a combination of oxygen and hydrogen, can be carried in sufficient quantities only if the two gases are liquified by reducing them to very low (cryogenic) temperatures. It is necessary to protect astronauts against very high and very low temperatures while they are in space or on the surface of the moon. The table below gives some space-related temperatures and other high and low temperatures.

Object or location	Temperature in degrees Fahrenheit
Sunlit side of moon	+ 250
Dark side of moon	- 250
Liquid oxygen (boiling point)	- 297
Liquid hydrogen (boiling point)	- 423
Liquid nitrogen (boiling point)	- 321
Fort Yukon, Alaska (lowest recorded in U.S.)	- 78
Death Valley, Calif. (highest recorded in N. America)	+ 134
Antarctica (lowest recorded in world)	- 127
Freezing point of water	+ 32
Boiling point of water	+ 212

a. The teacher and the pupils may make up and solve many problems like the following:
   1. How much colder is liquid hydrogen than liquid oxygen?
   2. How many degrees warmer is the sunlit side of the moon than liquid nitrogen?
   3. Is the sunlit side of the moon hotter or colder than the highest recorded temperature in North America (in Death Valley)?
   4. How much higher is the boiling point of water than the boiling point of liquid oxygen?

b. Plot the numbers in the above table on a number line.

TOPIC 7.07

Numbers and Counting

LEARNING ACTIVITIES

(4-6)

1. Count the number of stars in the sky by using a home-made star counter.
2. Locate solar system distances, perigee and apogee distances, and other space-related distances on a number line.
3. Practice with Roman numerals by referring to series of satellites identified with Roman numerals.

REINFORCEMENT

1. Make a counter by attaching two vertical sheets of cardboard at one edge with an angle of 30 degrees between. Fasten the vertical sheets to a horizontal sheet, making a viewing hole at the vertex. If a person holds the hole to his eye and keeps the counter steady, the number of stars that he can count will be one twenty-fourth of the total number visible in the sky (including both hemispheres).
2. Locate the following distances of the planets from the sun on a number line, using the Astronomical Unit, the average distance from the earth to the sun, as the unit of measure. (The Astronomical Unit, abbreviated A.U., is equal to approximately 93,000,000 miles.)

Planet	Distance from sun in A.U.
Mercury	.39
Venus	.72
Earth	1.00
Mars	1.5
Jupiter	5.2
Saturn	9.5
Uranus	19.2
Neptune	30.1
Pluto	39.4

If students are able to do the computation, have them convert the distances in the table above to miles, a unit of measure which is more familiar to them.

When a spacecraft is in an elliptical orbit about the earth, or other primary body, its greatest distance from the body is called its apogee, and its nearest distance is called its perigee. (Sometimes special names are given to these distances for primary bodies other than the earth. If the moon is the primary body, they are often called apolune and perilune.) News stories usually give the apogee and perigee distances in terms of the altitude in miles above the surface. However the space engineer usually prefers to have them expressed in terms of the distance from the center of the primary body. Knowing these maximum and minimum distances enables the engineer to obtain a great deal of information about the orbit. If the distances are equal, the body is in a circular orbit, and its orbital speed is constant. If they are not equal, the body is in an elliptical orbit. The greater the difference in the distances, the more elongated is the elliptical orbit. Speed is constantly changing in an elliptical orbit, with the body moving at its

greatest speed at perigee and its lowest speed at apogee.

The table below gives perigee and apogee distances for several orbiting bodies.

a. Have students locate the above distances on a number line.

b. Have students fill in the last two columns in the table above. (This is done by adding the radius of the earth, 3960 miles, to the altitude. For example, the perigee and apogee radius for Sputnik I are respectively 4083 and 4543 miles. In the case of Lunar Orbiter II, which was put into orbit about the moon, add the radius of the moon, 1080 miles.) The mathematics of orbital mechanics is made much simpler if apogee and perigee distances are expressed in terms of radius from the center of the primary body rather than in terms of the altitude above the surface.

c. Have students keep a file of news reports about satellites and make up their own tables of perigee and apogee distances.

3. The individual satellites in most series of NASA's unmanned or scientific satellites have been distinguished from each other by the use of Roman numerals. The following table gives a partial listing of series of satellites and their Roman numeral designations orbited through the fall of 1967.

Record data on the atmosphere, ionosphere, micrometeroids, earth's gravity field, etc.
- Explorer I - XXXIV

Stud sun and solar phenomena (Orbiting Solar Observatory)
- OSO I - IV

Study astronomy (Orbiting Astronomical Observatory)
- OAO I

Record data on environment around earth and in space (Orbiting Geophysical Observatory)
- OGO I and II

Record data on micrometeoroids
- Pegasus I - III

International satellites
- Great Britian: Ariel I - III
- Canada: Alouette I and II
- Italy: San Marco I and II

Investigate interplanetary space
- Pioneer I - VI

Photograph moon
- Ranger I - IX
- Lunar Orbiter I - V

Study surface of moon
- Surveyor I - V

Communications satellites
- Passive: Echo I and II
- Active repeater: Relay I and II; Telstar I and II
- Synchronous: Syncom I - III, Intelstat I and II

Record data about planets
- Mariner I - V

Weather satellites, to photograph earth from space
- Tiros I - X, Numbus I and II, Essa I - V

Two-man spacecraft
- Gemini III - XII

Orbiting body	Perigee Altitude (miles)	Apogee Altitude (miles)	Perigee Radius (miles)	Apogee Radius (miles)
Sputnik I	132	583	———	———
Explorer I	220	1580	———	———
Echo I	950	1050	———	———
Gemini V	101	217	———	———
Explorer XIV	175	61,000	———	———
Nimbus I	252	578	———	———
Orbiting Solar Observatory II	394	432	———	———
Lunar Orbiter II	27	1167	———	———

TOPIC 7.08

Measurement of distance and speed

LEARNING ACTIVITIES (4-6)

1. Use latitude and longtitude to locate points and measure distances on a globe of the earth.
2. Compare the apogee and perigee distances of satellites.
3. Compare speeds of common objects, aircraft, and satellites.

REINFORCEMENT

1. A degree of latitude measures about 69 miles. The distance between two meridians of longtitude is about 69 miles at the equator, and is zero at the poles. The average distance around the earth is about 24,900 miles. One way of doing this activity is to have the pupil lay a strip of paper on a globe of the earth, the edge passing through the points whose distance apart is to be measured. Mark the locations of the points on the paper. The distance can then be estimated by comparing the distance between the points with known distances on the globe.

City	Degrees Latitude	Longtitude
London	51 1/2 N	0
Rome	42 N	12 1/2E
Shanghai	31 N	121 1/2E
Tokyo	36 N	140 E
Sydney	34 S	151 E
Buenos Aires	35 S	58 W
New York	41 N	74 W
Chicago	42 N	88 W
Los Angeles	34 N	118 W

2. In the previous section a table of perigee and apogee distances of several types of satellites was given. Have students solve such problems as the following:

a. How much greater is the greatest perigee distance than the smallest perigee distance?
b. How much greater is the greatest apogee distance than the smallest apogee distance?
c. Find the difference between the apogee distance and the perigee distance for each satellite. (Remember that the smaller the difference, the more circular is the orbit.)
Rank the satellites in order, with the most nearly circular coming first and the most highly elliptical coming last.
d. Find the average of the perigee radius and apogee radius for each orbit, thus finding the average radius for the orbit.

3. The table below gives a variety of speeds in miles per hour. Have the students fill in the empty blanks.

The following questions are only suggestive of the types of problems that can be solved with the data below.

a. How much faster will the new supersonic airplane, expected to be built during the next few years, be than the present commercial jet airliners?
b. How many times as fast as the present jet airliner will the supersonic airliner travel?
c. How many times as fast is the modern jet airliner than the speed limit in your city? Than the expressway speed limit in your state?
d. Does the speed of a spacecraft in a circular orbit increase or decrease as the radius of the orbit increases?
e. How much faster does a spacecraft travel in an orbit 100 miles above the earth than it travels at an altitude of 22,300 miles? (At this altitude the spacecraft has a period of 24 hours and seems to remain stationary above a point on the earth.)
f. When a spacecraft orbits about a body with a smaller mass, like the moon, does its speed increase or decrease?

Residential speed limit in your city	?
Common highway speed limit in your state	?
Expressway speed limit in your state	?
Cruising speed of commercial jet airliner	575
Cruising speed of commercial supersonic airplane	1800
Spacecraft in circular orbits	
Altitude 100 miles above surface of earth	17,500
Altitude 500 miles above surface of earth	16,700
Altitude 1000 miles above surface of earth	15,700
Synchronous orbit 22,300 miles above surface of earth	6,880
Altitude 60 miles above surface of moon	3,600

TOPIC 7.09

Geometric Forms

LEARNING ACTIVITIES (4-6)

1. Study the geometric paths of gravitational orbits.
2. Study the shapes of manned and scientific satellites.

REINFORCEMENT

1. The orbits of manned spacecraft about the earth and of the planets about the sun are nearly circular. However there is always a small deviation from a true circle, so that the actual shape of closed orbits is always an ellipse. Sometimes the deviation from a circle is so small that it cannot be detected except by very accurate measurement. Although the mathematical properties of the ellipse cannot be studied in depth in grades 4 - 6, the teacher can explain and demonstrate some of its properties. Students should be taught the string and pencil construction for the ellipse, with the string looped about two thumb tacks or other fasteners placed at the foci. Show how the ellipse becomes long and narrow when the foci are moved apart.

An orbit which permits escape from the earth must necessarily be an open orbit. The escape orbit with minimum velocity is a parabola. Students can be taught string and pencil constructions for the parabola. The use of the parabola for reflectors in flashlights and headlights and in architecture makes an interesting topic. When the escape velocity is greater than the minimum, the orbit becomes a hyperbola. Show students the difference between the parabola and the hyperbola.

If a conic section model is available, show students how the circle, ellipse, parabola, and hyperbola can be obtained by cutting a cone with a plane. Students can make conic sections by cutting paper cones with a sharp knife.

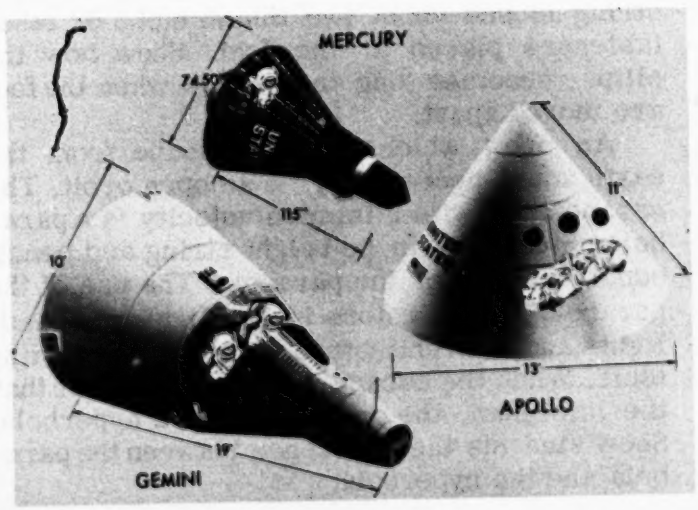
Whenever a body is moving about any primary body under the influence of gravity alone, its path will be one of these conic sections, with the primary body located at a focus of the conic section.

2. Students in grades 7 - 8 should be able to identify common geometric solids such as spheres, zones of a sphere, cones, frustrums of cones, cylinders, and the like. Have them identify the various parts of manned and scientific spacecraft. Some examples are shown below.

The Gemini spacecraft is composed essentially of a zone of a sphere, frustums of a cone, and a cylinder as was Mercury.

The Apollo capsule is composed essentially of zones of a sphere and the frustum of a cone.

Syncom, the stationary or synchronous satellite, is composed primarily of a cylinder and the frustum of a cone.



TOPIC 7.10

Position

LEARNING ACTIVITIES

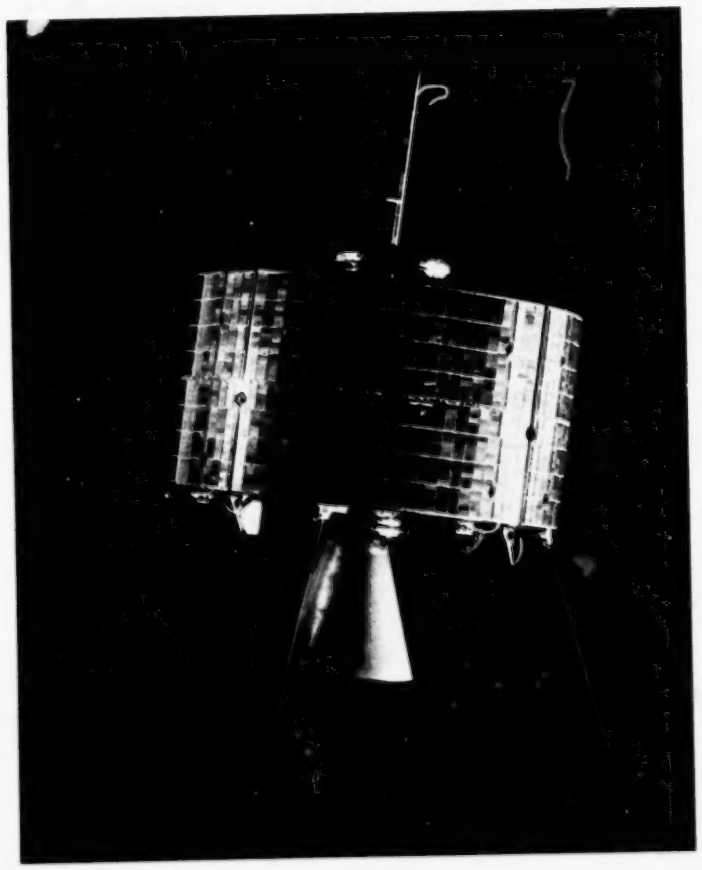
(4-6)

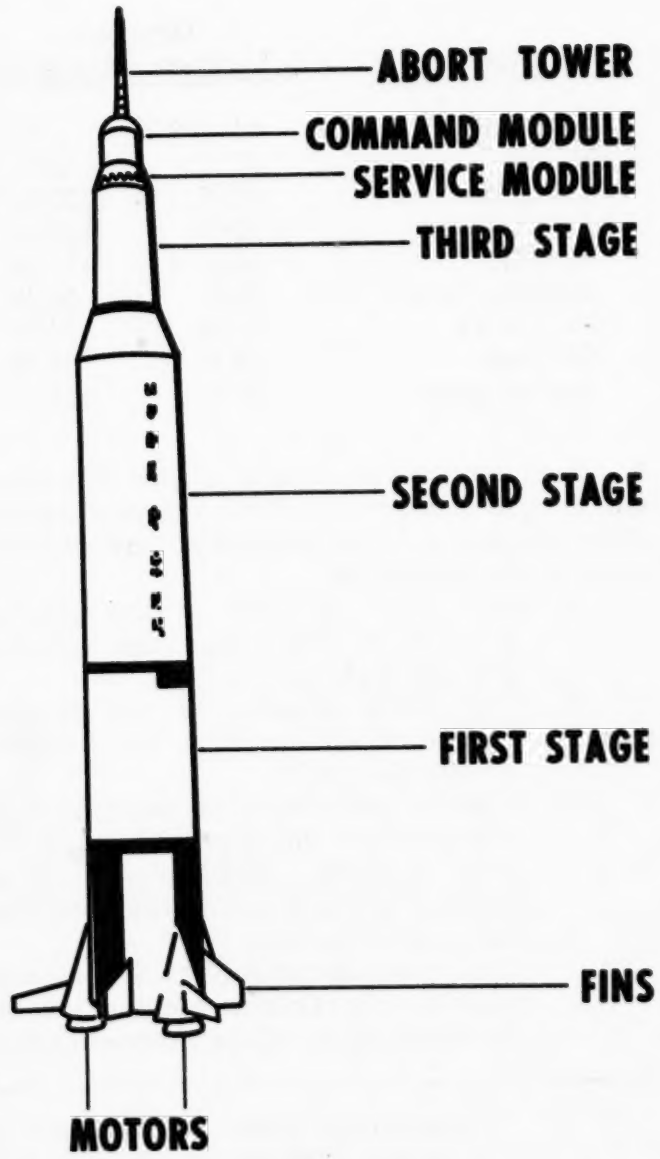
1. Teach ideas of up, down, above, below, middle, front, and other concepts of position by using space related objects.

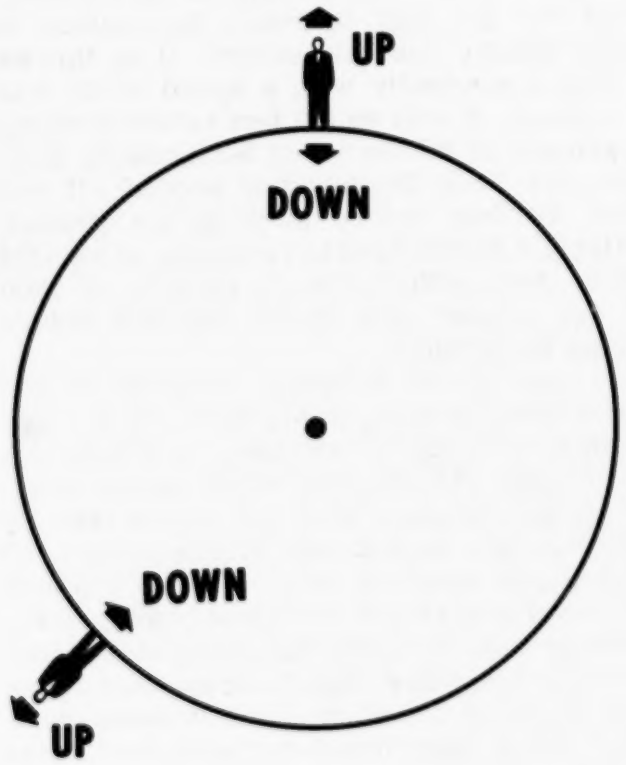
REINFORCEMENT

1. Any of the NASA launch vehicles could be used to teach ideas of position. The most complicated launch vehicle designed to date, the one with the most parts, is the Saturn V. The large section at the bottom is the First Stage, with the fins at the side and the motors below. The Abort Tower (used for escape if necessary) is on top. The Second Stage is between the First and Second Stages, and the like. The Command Module is below the Abort Tower. Many illustrations of position can be obtained from this and other launch vehicles.

Syncom

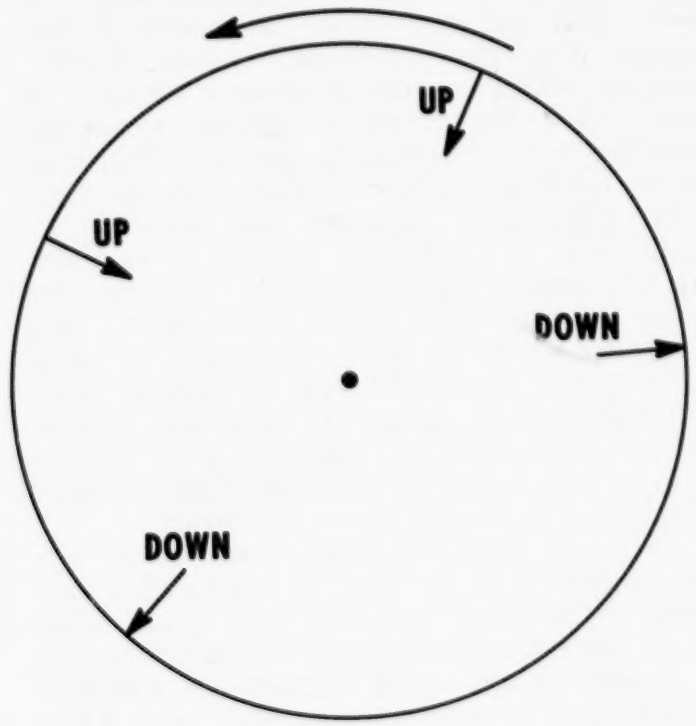






Ideas of down and up may be developed by referring to positions on the earth, or on any body with enough mass to have a measureable gravity field. Regardless of where one is standing, down is toward the center of gravity, up is away from the center of gravity.

If the students have any knowledge of the "apparent weightlessness" which exists in an orbiting spacecraft, they may wish to discuss the meaning of down and up in a space capsule in orbit. There is no down or up, and any object in the spacecraft, unless it is pushed by some force, remains suspended wherever it is, and seems to "float" in space. If we tie a weight to the end of a string and whirl the weight in a circle, the string pulls on the weight. In the same manner, if a person were standing inside a rotating cylinder, there would be a push against the person by the wall of the cylinder. Down would then be away from the center, and we would have by rotation created an "artificial" gravity. It is possible that this method of rotation will be used to create a down and up in orbiting space stations.



TOPIC 7.11

Computation

LEARNING ACTIVITIES

(4-6)

1. Compute the time required for light or radio signals to make the round trip to the moon, sun, satellites, or other star systems.
2. Compute the distance traveled by a synchronous satellite during one orbit.

REINFORCEMENT

1. Radio signals and light travel with the same speed, about 186,000 miles per hour. Find the time needed to make the following round trips from the surface of the earth.

Object	Distance
Gemini spacecraft	100 miles
Synchronous satellite	22,300 miles
Surface of moon	234,000 miles
Surface of sun	93,000,000 miles
Proxima Centauri (the star nearest the earth)	4.3 light years
Polaris (the pole star)	465 light years

2. A synchronous satellite travels at about 6880 miles per hour. How far will it travel during one day (24 hours)? The radius of the circular orbit of a synchronous satellite, measured from the center of the earth, is about 22,300 + 3960 miles, or 26,260 miles. Find the circumference of this circle. Does the answer agree approximately with the distance found above for the number of miles traveled by the satellite in one day?

TOPIC 7.12

Measurement of weight and volume

LEARNING ACTIVITIES

(4-6)

1. Compare weights on the moon with weights on the earth.
2. Compute the effects of the light weight on the moon on the physical activities of a person on the surface of the moon.
3. Use Newton's inverse square law of gravitational attraction to find the weight of objects in space above the earth.

REINFORCEMENT

1. The weight of an object is produced by the "pull" of gravity. The force of gravity on the moon is one-sixth that on the earth. Thus if a bathroom scale (of the spring type) reads 120 pounds while a woman is standing on it at the surface of the earth, the scale would read only 20 pounds if the woman could stand on it on the surface of the moon. That is, a person will weigh one-sixth as much on the moon as on the earth.

Find the moon weight which corresponds to each earth weight:

Weight on earth	Weight on moon
Man 160 lb.	_____
Automobile 3000 lb.	_____
Woman 350 lb.	_____
Suitcase 30 lb.	_____
Child 32 lb.	_____

2. With a given amount of effort, a person would be able to lift on the moon six times the weight that he can lift on earth. If a person lifts the following weights on earth, what weights could he lift on the moon with the same amount of effort: 40 lb., 75 lb., 120 lb., 200 lb., 1259.5 lb. (World record). Compute the weight that could be lifted on the moon for other earth weights of interest to the class.

An athlete would be able to pole vault or high jump much higher on the moon than on the earth. However if a man can high jump 5 feet on the earth, it would be erroneous to assume that he can high jump six times as far, or 30 feet, on the moon. Let us study briefly the action of the body during high jumping or pole vaulting.

The center of gravity of the average man is a little less than 3 1/2 feet above the ground. If he clears a five-foot bar, it means that he must lift his center of gravity only one and one-half feet to get it even with the bar, and then he needs to get it about one-half foot higher to clear the bar. He then rotates his body to the horizontal to get over the bar, and straightens out to the vertical as he drops to the ground. Thus to clear a five-foot bar, he needs to lift his center of gravity only two feet. With the same effort he could lift his center of gravity 12 feet on the moon. Therefore he would be able to clear a bar 11 1/2 feet above his center of gravity (allowing one-half foot clearance to get over the bar), or 11 1/2 plus 3 1/2 or 15 feet above the surface of the moon. Similarly, if a man can pole vault over a 16-foot bar on earth, he must lift his center of gravity about 13 feet. On the moon he could lift it 78 feet. Thus the bar that he could clear on the moon would be about 77 1/2 feet plus 3 1/2 feet or 81 feet above the surface of the moon. Have students compute the heights on the moon that would correspond with certain heights of interest to them for high jumping or pole vaulting on the earth.

When a baseball pitcher throws a ball horizontally, the vertical and horizontal motions do not interfere with each other. That is, it takes the same length of time for the ball to reach the ground if he drops it or throws it horizontally (unless he throws it so fast that it goes into orbit). If a ball is dropped a distance of four feet on the earth, the time required for the ball to reach the surface is almost exactly one-half second. If he throws the ball horizontally with a speed of 20 feet per second, it will go ten feet before striking the ground. If he throws it horizontally at 60 miles per hour (88 feet per second), it will travel 44 feet before striking the ground. Similarly a bullet fired horizontally at a height of four feet with a muzzle velocity of 1200 feet per second will travel 600 feet before striking the ground.

On the moon, however, because of the moon's lower gravity, it will take $\sqrt{6}$ or about 2.5 times as long for an object to fall from a given height. Thus the ball above thrown horizontally at a height of four feet with a velocity of 20 feet per second will strike the ground in 2.5 times one-half, or 1.25 seconds, and it will travel a distance of 25 feet before striking the ground. Have students compute the distance that the other objects mentioned above would travel on the moon. Have students make up and solve other problems using horizontal velocities of interst to them.

3. Newton's inverse square law of gravitation is of the form

$$F = \frac{K}{d^2},$$

where d is the distance from the center of the earth, or other body involved. An object on the surface of the earth is one radius (3960 miles) from the center. If it is moved to a point one radius above the surface into space, its distance d from the center is 2r, so that $d^2 = (2r)^2 = 4r^2$. That is, the force of gravitation is divided by four, and the weight of the object will be one fourth of what it was on the surface. Given the following weights on the surface of the earth, 40 lb., 100 lb., 1 1/2 tons, 20 tons, find what the weight would be at the following altitudes above the surface: 1 earth radius, 7920 miles, 3 earth radii, 22,300 miles.

TOPIC 7.13

Fractions and Ratios

LEARNING ACTIVITIES

(4-6)

1. Find the ratios of the diameters of bodies in the solar system.
2. Compute dimensions for a scale model of the solar system.
3. Find the thrust-to-weight ratios of NASA launch vehicles.

REINFORCEMENT

1. The following table gives diameters of bodies in the solar system.

Body	Diameter in miles
Earth	7,920
Jupiter	88,640
Mars	4,200
Mercury	3,100
Moon	2,160
Neptune	31,000
Pluto	?
Saturn	74,500
Sun	864,000
Uranus	32,000
Venus	7,700

How many times greater is the diameter of the sun than that of the Earth, Mercury, Mars, Jupiter, Neptune? How many times greater is the diameter of the earth than that of Mars, Mercury, the moon, Venus?

2. Using a scale of 10,000 miles = one inch, compute dimensions for a scale model of the solar system, finding the diameter of each body according to this scale and the distance of each planet from the sun. Would it be physically possible to construct this model?
3. Use the table given in the next section on Graphs and Tables to find the thrust-to-weight ratio of each launch vehicle described. (The thrust must be greater than the weight or the vehicle will not be lifted from the ground.)

TOPIC 7.14

Graphs and Tables

LEARNING ACTIVITIES

(4-6)

1. Make tables of space-related data.
2. Construct bar and line graphs with space-related data.

REINFORCEMENT

1. The following table gives data on a group of NASA launch vehicles.
   a. Arrange the above data into a systematic table showing the lift-off thrust of each launch vehicle.
   b. Make a systematic table showing the total weight for each launch vehicle.
2. Using the above data, make a bar graph showing the weight that each launch vehicle can put into a 100 nauticle-mile orbit above the surface of the earth.

Vehicle	Total Weight (pounds)	First Stage or Lift-off Thrust (pounds)	Payload for 100 Nautical-Mile Orbit (pounds)
Atlas-Centaur	300,000	368,000	8,500
Delta	114,200	170,000	
Saturn V	6,200,000	7,500,000	240,000
Thor-Agena D		170,000	1,150
Uprated Saturn I	1,294,000	1,600,000	34,000
Gemini-Titan II	300,000	430,000	7,000
Scout	38,500	86,000	
Atlas-Agena D		368,000	5,000

TOPIC 7.15

Measurement

LEARNING ACTIVITIES

(7-9)

1. Express astronomical distances in various space-related units, such as miles, light years, Astronomical Units, and parsecs.
2. Convert statute miles to nautical miles, and vice versa.
3. Express speeds in feet per second, miles per hour, knots, and Mach numbers.
4. Express space-related numbers with scientific notation.
5. Study the method used by Eratosthenes for finding the size of the earth.

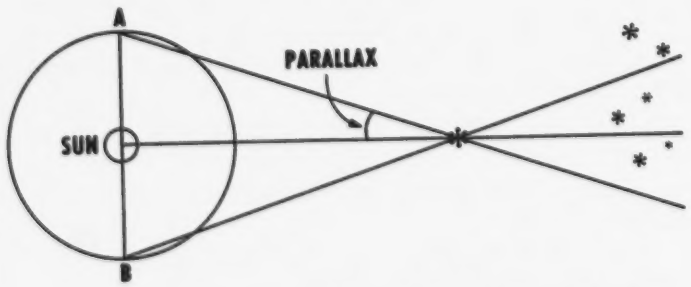
REINFORCEMENT

1. The mile is the statute mile, defined by law to have a length of 5280 feet.

The light year is the number of miles that light travels in one year at the rate of 186,300 miles per second. One light year equals approximately 5.88×10^{12} miles.

The Astronomical Unit (A.U.) is the average distance from the earth to the sun, and equals 93,000,000 miles.

The word parsec is an abbreviation of the words "parallax of one second." Parallax is the difference in direction which the same object seems to have when viewed from two different points. When the parallax of distant stars is being measured, the radius of the earth's orbit about the sun is used as the base line.



If sightings of a star are taken on dates six months apart, such as January 1 and July 1, when the earth is at points A and B respectively, the direction of the star will seem to have shifted slightly when viewed against the background of more distant stars. The parallax is measured in seconds of arc, and the angle used is usually half of the total parallax. This parallax is referred to as the heliocentric parallax. When the angle of parallax is one second of arc, the distance to the star is called one parsec. The parsec is equal to 3.26 light years, 206,265 A.U., or 1.92×10^{13} miles.

a. Using the above data, find the number of miles in a light year, the number of A.U. in a light year, the number of miles in a parsec.

b. The diameter of our Milky Way galaxy is about 25,000 parsecs. Express this diameter in A.U., light years, and miles.

c. Following are the distances to several stars: Vega 8.1 parsecs, Sirius 8.6 light years, Polaris (the pole star) 465 light years. Express these distances in the other units defined above.

2. The statute mile contains 5280 feet. The nautical mile was originally the length of one minute of arc of any great circle of the earth, and thus had a length of about 6080 feet. (By international agreement the length of the nautical mile has been set at 6076.11549 international feet. However it is suggested that the old definition of 6080 feet be used in these problems.)

a. Have students verify that one nautical mile equals approximately 38/33 miles.

b. Express the following distances in statute miles: 100 nautical miles, 450 nautical miles, 21,600 nautical miles.

c. Express the following distances in nautical miles: 100 statute miles, 800 statute miles, 22,300 statute miles.

3. A knot is one nautical mile per hour. The Mach number is the speed of sound in the air through which the body is moving. The speed of sound decreases as the temperature of the air decreases. In dry air at ordinary temperatures, Mach 1 = about 1100 feet per second. A speed greater than Mach 1 is called supersonic, while one equal to Mach 5 or greater is called hypersonic.

a. Have students change miles per hour to feet per second. Find a convenient multiplier by which speeds in miles per hour can quickly be changed to feet per second. (The multiplier is 22/15. The reciprocal will change feet per second to miles per hour.)

b. Change 550 miles per hour to a Mach number. To feet per second.

c. A supersonic plane would travel at a high altitude at which the speed of sound would be about 660 miles per hour. What would be the speed in miles per hour of such a plane traveling at Mach 2.5? In feet per second?

d. Express 30 knots in miles per hour. 60 miles per hour in knots.

e. Express the speed of a hypersonic plane flying at high altitude at Mach 6 in miles per hour. In knots.

4. Write the following numbers in scientific notation.

a. 239,000 miles, center of earth to center of moon. Express in A.U.

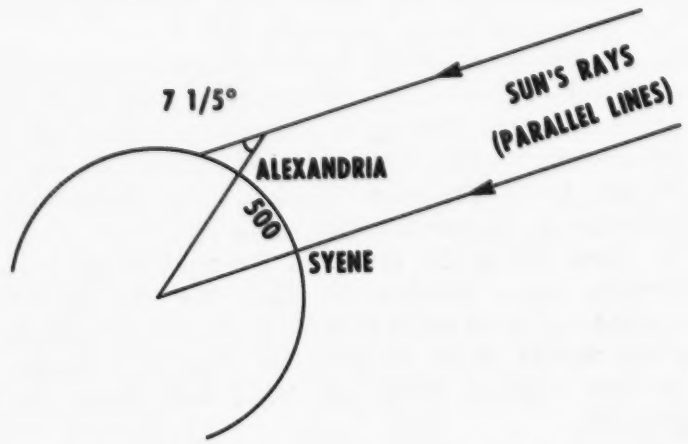
b. 25,000 miles per hour.

c. 2797 million miles, average radius of orbit of Neptune.

d. The teacher and student, by reading popular literature, can find many other space-related distances, large and small, to express in scientific notation.

5. Eratosthenes knew that on a certain day of the year the sun was directly over Syene because he saw its reflection in the bottom of a well located there. He also knew that at this same time the rays of the sun made an angle of about 7 1/5 degrees with a pyramid 500 miles north at Alexandria.

a. Have students study this data and determine how Eratosthenes concluded that the diameter of the earth was 50 x 500 or 25,000 miles. (360 degrees divided by 7 1/5 degrees equals 50.)



TOPIC 7.16

Equations

LEARNING ACTIVITIES

(7-9)

1. Use Newton's Law of Universal Gravitation to derive a formula for finding the weight of an object at any given altitude above the surface of the earth. Of the moon.
2. Find the velocities and accelerations of common vehicles.
3. Compute the velocity of satellites in circular orbits.

REINFORCEMENT

1. Newton's law states that

$$F = \frac{GMm}{d^2},$$

where F is the force which attracts two bodies to each other, G is the constant of universal gravitation, M and m are the masses of the two bodies, and d is the distance between their centers of gravity.

Let M be the mass of the earth. For a given body of mass m on the surface of the earth, the numerator is a constant, which we may call K. If the body is on the surface of the earth, its distance from the center of gravity of the earth is r, and the attraction between it and the earth can be called F_e. Then

$$F_e = \frac{K}{r^2}.$$

If the small body is at an altitude h above the surface of the earth, its distance from the center of gravity of the earth is r + h, and the attraction between it and the earth can be called F_h. Then

$$F_h = \frac{K}{(r+h)^2}$$

If we find the ratio of F_h to F_e and simplify, we obtain the equation

$$\frac{F_h}{F_e} = \frac{r^2}{(r+h)^2} .$$

It is force or "pull" of gravity which gives weight to objects. Let w_e be the weight of an object on the surface and w_h be its weight at altitude h. Then

$$\frac{w_h}{w_e} = \frac{r^2}{(r+h)^2} .$$

Solving the equation for w_h, we obtain a more convenient form of the equation,

$$w_h = \frac{r^2}{(r+h)^2} w_e .$$

Suppose an object weighs 100 pounds on earth, and is placed 50 miles above the surface of the earth. Then r = 3960 and (r + h) = 4010. Substituting in the equation, we find that w_h, the weight at an altitude of 50 miles, is 97.5 pounds.

a. The Mercury spacecraft weighed about 3000 pounds and were put into nearly circular orbits 100 miles above the surface of the earth. What was the physical weight of the spacecraft at this altitude?
b. What percent of its surface weight does an object have when at an altitude of 500 miles? 200 miles? 22,300 miles?
c. An object in orbit behaves as it were weightless. What is the difference between "apparent weightlessness" and physical weightlessness? Would an object with mass ever by physically weightless? If so, where? (At an infinite distance from every body with mass, or at a neutral point where the vector sum of all of the gravity forces is zero.)

The above formula for the weight of a body h distance above the surface would apply to any body, such as the moon. The only change needed in applying it to the moon would be to let the value of r = 1080, the radius of the moon, instead of 3960.

a. Suppose that an object weighing 100 pounds on the surface of the moon is moved up to the following altitudes: 50 miles, 100 miles, 200 miles, 500 miles, 1080 miles. What would its physical weight be at these altitudes? (The answers should be respectively 92, 84, 71, 47, and 25 pounds. Remember that this object would weigh about 600 pounds on the surface of the earth.)

2. Velocity or speed is simply distance covered per unit of time. If v_a is the average velocity, t is the elapsed time, and s is the distance,

$$v_a = \frac{s}{t} .$$

(Actually velocity and speed are not synonymous terms, since velocity is a vector quantity involving both magnitude and direction, while speed is a scalar quantity involving magnitude only. However it is not necessary to make this distinction on the junior high school level.) Note that the average velocity is half of terminal velocity, assuming that the initial velocity was zero.

Acceleration is change in velocity per unit of time. If v is the terminal velocity (or total change in velocity if the body did not start from rest), and t is the elapsed time,

$$a = \frac{v}{t} \quad .$$

When a body falls freely near the surface of the earth, the force of gravity (neglecting air resistance) makes it fall faster and faster, giving it an average acceleration or gain in speed of 32.2 feet per second during each second of fall. This acceleration of 32.2 feet per second per second is often called one g. A gain in speed of 64.4 feet per second per second would be an acceleration of 2 g's.

The junior high school student should, for convenience in use, be able to solve each of the above equations for any one of the other variables.

a. If a jet airplane travels 2,500 miles at an average speed of 575 miles per hour, what will the elapsed time be?
b. If an automobile can go from a standing start to 60 miles per hour in 11 seconds, what is the acceleration in miles per hour per second, in feet per second per second, and in g's?
c. When a spacecraft is being launched, it must gain speed very rapidly, since the burning time of a modern launch vehicle is short. If a vehicle reaches an acceleration of 8 g's at burnout of the first stage, how fast is the vehicle gaining speed at that moment in feet per second per second? In miles per hour per second?
d. A manned capsule entering the earth's atmosphere may experience a deceleration (reduction in velocity) of about 5 g's when the main parachute opens. At what rate is the capsule slowing down at that moment in feet per second per second? In miles per hour per second?

When an elevator in an office building moves up from rest, it has an acceleration until it reaches its "cruising" speed. Then it moves with a constant speed until it begins to slow down (decelerate) for coming to a stop. When the elevator begins to rise, it pushes against the feet of the passengers. If a person standing on the elevator were to judge by the sensations in his body, he might conclude that he had suddenly gained weight. In fact, if he were standing on a bathroom-type spring scale, the scale would show an increase in reading. The scale readings are all that we need to measure the acceleration of the elevator.

According to Newton's Second Law of Motion, the acceleration produced by a force is directly proportional to the force. That is, the ratio

$$\frac{f}{a}$$

is a constant. If we let a body fall near the surface of the earth, the force acting on the body is its weight w, and the acceleration produced is g. We may therefore write the equation

$$\frac{f}{a} = \frac{w}{g} \quad .$$

Suppose that a person weighing 140 pounds notices that when the elevator begins to rise, the reading on the scale increases to 157 pounds. Then f = 17, w = 140, and g = 32.2. Solving, we find that a is approximately 4. Thus the acceleration of the elevator is about 4 feet per second per second, or 1/8 g. If the period of acceleration lasted for one and one-half seconds, the elevator reached a cruising speed of 6 feet per second. (An acceleration of 4 feet per second per second and a cruising speed between 4 and 6 feet per second are about average for elevators in medium-height office buildings.)

a. If a person weighs 160 pounds, what will the scale read if the acceleration is 4 feet per second per second? If the period of acceleration is one second, what is the cruising speed of the elevator?
b. What will the scale read if a 160-pound person is on an elevator with an acceleration of 7 feet per second during each second? What is the cruising speed of the elevator if the period of acceleration lasts for 4 seconds? (Accelerations and cruising speeds of this order are found on high-speed elevators in some new office buildings.)
c. If a girl weighing 120 pounds experiences an increase in scale reading of 12 pounds, what is the acceleration of the elevator?

d. Have students take the family bathroom scales (and a stopwatch if possible) to various elevators and measure their accelerations and cruising speeds.

The above exercises can be used to help a student understand the sensations of an astronaut in a capsule being launched into orbit. Suppose that at burnout of a stage of the launch vehicle, the acceleration has reached a peak of 7 g. Then we find by substituting 7 g for a in the above equation that f = 7w. Then the astronaut feels, and acts, as though 7 times his normal weight had been added to his body weight. He is gaining speed at that moment at the rate of 7 x 32.2 or 258 feet per second per second, or about 153 miles per hour during each second.

3. Newton's First Law of Motion says that an object in motion will continue to move in a straight line unless some external force acts on it. If a body is to follow a circular path, a constant central, or centripetal, force must act on it. If an object is tied to a string and whirled in a circle, this force is supplied by the tension in the string. It is shown in physics textbooks that the magnitude of this force is

$$F = \frac{mv^2}{r}.$$

When a satellite is moving in a circular orbit about the earth, the central force is produced by the force of gravitation. We may therefore write the equation

$$\frac{mv^2}{r} = \frac{GMm}{r^2}$$

Solving for v, we obtain

$$v = \sqrt{\frac{GM}{r}} \quad .$$

If we use miles and seconds as our units of measurement, the value of GM is approximately $9.56(10)^4$, and the equation becomes

$$v = \sqrt{\frac{9.56\ (10)^4}{r}} \quad ,$$

in which r is the radius of the orbit in miles from the center of the earth and v is the velocity in miles per second. If we multiply this velocity by 3600, the number of seconds in an hour, we have the velocity in the more common terms of miles per hour. If we wish to find circular orbital velocity at an altitude of 100 miles above the surface of the earth, r = 100 + 3960 = 4060. Then

$$v = \sqrt{\frac{9.56\ (10)^4}{4060}} = \sqrt{23.5} = 4.85$$

miles per second, or 4.85 x 3600 = about 17,500 miles per hour.

a. Have students compute circular orbital velocities at the following altitudes: 0 miles (surface velocity), 200 miles, 500 miles, 1000 miles, 22,300 miles. (The answers in miles per hour should be approximately 17,600; 17,100; 16,700; 15,700; 6,880.)

TOPIC 7.17

Graphs and tables

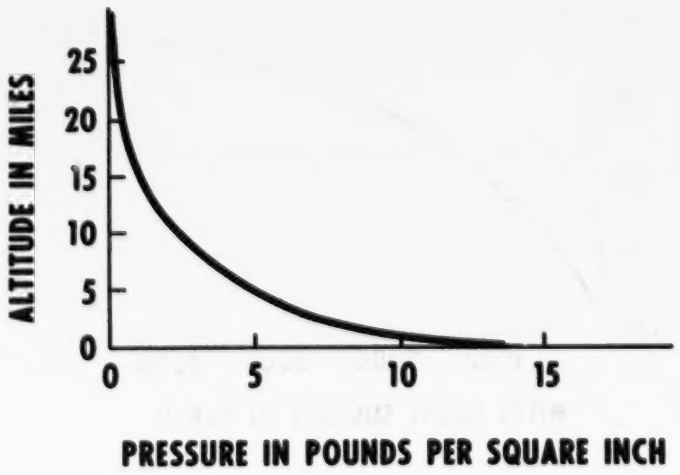
LEARNING ACTIVITIES

(7-9)

1. Construct a table or graph showing the relationship between altitude and air pressure.
2. Make a line graph showing the relationship of altitude above the earth to the weight of an object.
3. Make a table showing the relationship of circular orbital velocity to altitude above the earth's surface.

REINFORCEMENT

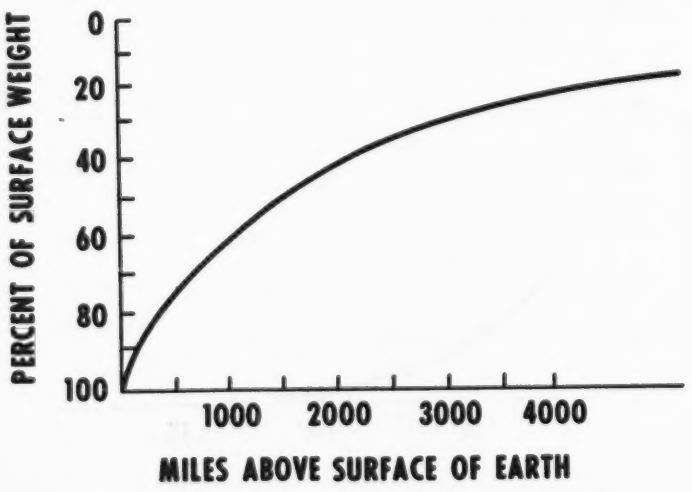
1. Air pressure is approximately halved for each three and one-quarter miles of vertical ascent. Using this rule, construct a table or line graph showing air pressure at various altitudes above the surface of the earth. The average pressure at the surface is 14.7 pounds per square inch. A line graph could be constructed as shown below.



2. Using the equation developed in the previous section for finding the weight of an object at a given altitude above the surface of the earth, compute the data needed to complete the table below.

Miles Above Surface	Percent of Surface Weight
50	97.5
100	95
200	?
500	79
1,000	64
1,500	?
2,000	44
2,500	?
3,000	33
3,500	?
4,000	25

Arrange the above data in a line graph like the one below. How high would an object have to be in order for its weight to be zero?



3. Using the formula developed in the preceding section for finding circular orbital velocity, compute the additional data needed to construct the table below. (The velocities for altitudes of 100, 2,000, 37,700, and 235,000 miles are respectively 17,500; 14,400; 5,450; and 2,280. The last velocity will be recognized as that of the moon. Since the center of the moon is about 235,000 miles above the surface of the earth, the radius of its orbit, measured from the center of the earth, is 239,000 miles. It traverses this orbit in about 27 1/3 days. The student may wish to compare the above velocity with that actually needed by the moon to move through a circle with radius 239,000 miles in 27 1/3 days.)

Altitude in Miles Above Surface of Earth	Velocity in Miles per Hour
0 (surface orbit)	17,600
100	?
500	16,700
1,000	15,700
2,000	?
22,300	6,880
37,700	?
235,000	?

TOPIC 7.18

Computation

LEARNING ACTIVITIES

(7-9)

1. Compute the weight (pressure) of the atmosphere on each square foot at sea level.
2. Compute the total weight of the atmosphere.
3. Compute the individual pressures of the oxygen and nitrogen in the atmosphere for various altitudes.

REINFORCEMENT

1. The average pressure of the atmosphere at sea level is 14.7 pounds per square inch. Multiply this value by 144, the number of square inches in a square foot, and find the total pressure per square foot.
2. The average radius of the earth is 3960 miles. Using the formula for the area of a sphere, find the total surface area in square feet. Multiply this result by the weight per square foot and find the total weight of the atmosphere.
3. The atmosphere is composed by volume of 21 percent oxygen, 78 percent nitrogen, and one percent of other gases. This composition is practically constant to an altitude of 60 miles or more. The part of the atmospheric pressure exerted by the oxygen in the air at sea level is approximately 21 percent of 14.7 pounds or 3.1 pounds, if we base the computation on volume.
   a. Compute the pressure exerted by the nitrogen in the air at sea level.
   b. Using the rule previously given relating air pressure to altitude, find the partial pressures of the oxygen and nitrogen at an altitude of 3 1/4 miles. 6 1/2 miles.
   c. Estimate the partial pressure of the oxygen at the top of Mt. Everest, 29,028 feet above sea level.

TOPIC 7.19

Exponential Equations

LEARNING ACTIVITIES

(10-12)

1. Develop a formula which relates atmospheric pressure to altitude.
2. Use the above formula to solve problems related to pressure and altitude.

REINFORCEMENT

1. In the activities discussed for the lower grade levels, the simple rule was given that atmospheric pressure is approximately halved for each 3 1/4 miles of vertical ascent. The rule will be much more useful if we can express it in an equation. We might proceed from specific examples to a generalized statement. The pressure P at an altitude of $3\frac{1}{4}$ miles is $14.7(\frac{1}{2}) = 14.7(\frac{1}{2})^{\frac{3\frac{1}{4}}{3\frac{1}{4}}}$.

The pressure of an altitude of $6\frac{1}{2}$ miles is half of that found at $3\frac{1}{4}$ miles, or

$14.7(\frac{1}{2}) = 14.7(\frac{1}{2})^2 = 14.7(\frac{1}{2})^{\frac{6\frac{1}{2}}{3\frac{1}{4}}}$. Similar numerical examples lead us to the conclusion that

$$P = 14.7\,(\tfrac{1}{2})^{\frac{A}{3\frac{1}{4}}}.$$

where A is the altitude in miles for which the pressure is desired. It is clear that when the exponent $\frac{A}{3\frac{1}{4}}$ is an integer, the pressure can be found by simple computation. When the exponent is not an integer, the value of P can be found by linear interpolation between values of P for which the exponent is an integer.

a. Find pressures at various altitudes, such as the top of Pikes Peak (14,108 feet), 40,000 feet, 13 miles, 20 miles, 50 miles.
b. What altitude is just above 99 percent of the atmosphere?
c. What is the pressure when A = 0? Interpret this result.
d. What value of A is needed to make P = 0?
e. The ability of a person to do physical activity depends not upon the total atmospheric pressure but upon the availability of a normal (sea level) supply of oxygen. The composition of the atmosphere is 21 percent oxygen, 78 percent nitrogen, and one percent other gases. Oxygen weights about 1.14 times as much as nitrogen. Thus the 78 parts of nitrogen would weigh 78 units, the 21 parts of oxygen would weigh about 24 units, and we shall assume that the remaining gases weigh one unit. Then the pressure of the oxygen by weight is 24 parts out of 103, or 23.3 percent of 14.7 pounds per square inch. (Basing our computation on weight rather than volume agrees more closely with actual experience.) If a person were breathing pure oxygen at this pressure, his rate of intake of oxygen would be the same as at sea level. Have students compute the partial pressure of the oxygen based upon weight. What altitude would correspond to this pressure?

TOPIC 7.20

Conic Sections

LEARNING ACTIVITIES

(10-12)

1. Study the relationship of the conic sections to gravitational orbits.
2. Compute circular orbital velocities around the earth and other bodies.
3. Derive and apply the formula for minimum escape velocity.
4. Study the relationship of apogee and perigee to the eccentricity of an elliptical orbit.
5. Compute the velocities at apogee and perigee of satellites in elliptical orbits.
6. Compute the changes in velocity which must be given to a satellite to circularize or modify the orbit.
7. Apply Kepler's Second Law of Motion to the behavior of a satellite in an elliptical orbit.

REINFORCEMENT

1. It is likely that students will be introduced informally to conic sections in junior high school or in geometry courses in high school. The mathematical properties of the conics cannot, of course, be investigated until the student studies analytical geometry. Thus the depth to which the teacher can go in discussing this material with students will be determined by their mathematical maturity.

There is no complete agreement as to the terminology to be used in discussing the paths of spacecraft. In this report we shall use the following definitions. When a body is moving under the influence of gravity alone, we shall call its path an orbit. When its path is being influenced by propulsion or other forces in addition to gravity, we shall call its path a trajectory.

If we use the above definition of an orbit, then all gravitational orbits are conic sections. Closed orbits are circles or ellipses. Open, or escape, orbits are parabolas or hyperbolas. A body following an open orbit with reference to the earth will never return to earth. It may go into a closed orbit later about another celestial body, probably the sun.

a. Have students learn the shapes of open and escape orbits. Have them trace the various conic sections, using string and ruler or some of numerous other methods that are available. Have them understand the difference between a circle and an ellipse, and between a parabola and a hyperbola. Show by means of a conic section model how the various conics may be formed by cutting a cone with a plane.

2. Most of us understand from experience that a body will follow a circular path only if a constant force pushes it toward the center. An example is a weight being whirled at the end of a string. The central force is supplied by the tension in the string. The magnitude of the central force is

$$F = \frac{mv^2}{r},$$

where m is the mass of the body, v is its velocity in feet per second, and r is the radius of the circle in feet. If the string breaks, eliminating the central force, the weight flies off in a straight line. In the case of an orbiting satellite, the central force is supplied by gravity, expressed by Newton's Law as

$$F = \frac{GMm}{r^2}.$$

Setting the two forces equal and solving for v yields immediately

$$v = \sqrt{\frac{GM}{r}}.$$

G is the constant of universal gravitation and M is the mass of the earth or other primary body. Their product is therefore a constant, and if we express its value in miles and seconds, we get the value $9.56\ (10)^4$.

Thus the formula

$$v = \sqrt{\frac{9.56\ (10)^4}{r}}$$

will give the velocity in miles per second for any body in circular orbit r miles from the center of the earth. If the altitude h of the spacecraft above the surface of the earth is given, then $r = 3960 + h$. For example, if $h = 100$, as with the Mercury spacecraft,

$$v = \sqrt{\frac{9.56\ (10)^4}{4060}} = \sqrt{23.5} =$$

4.85 miles per second, or 4.85 x 3600 = about 17,500 miles per hour.

a. Have students compute circular orbital velocities for various altitudes above the earth. (For a series of examples and answers, see the section for Grades 7 - 9.)

This formula can be used to find the velocity in circular orbits about any primary body, if we know the mass of the body. The easiest way to handle the mass of a primary body, other than the earth, is to express its mass as a multiple of the mass of the earth. For example, the mass of the moon is .012 times the mass of the earth, or .012 M. Therefore the above formula applies to orbits about the moon if we change the numerator to $9.56\ (10)^4(.012)$. For example, velocity in a circular orbit 60 miles above the surface of the moon is easily found as follows:

$$v = \sqrt{\frac{9.56\ (10)^4\ (.012)}{1080+60}} = \sqrt{1.006} =$$

1 mile per second or 3600 miles per hour. The following table will be useful in studying various orbits.

Body	Mass (Earth = 1)	Diameter in miles
Moon	.012	2,160
Mars	.11	4,200
Venus	.81	7,700
Jupiter	317	88,640
Sun	330,000	864,000

b. Have students find circular orbital velocities about the moon at the following altitudes in miles: 0 (surface orbit), 50, 100, 500.

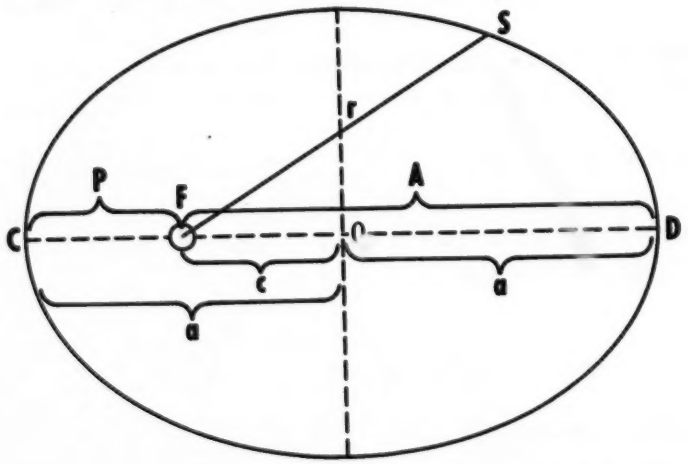
c. Have students find circular orbital velocities at the above altitudes about the other bodies in the table above. If time does not permit, compute velocities for at least altitudes of 0 and 500 miles. Can any generalization be made about the relationship of orbital velocity at a given altitude to the mass of the body? Can you justify the generalization from the equation?

3. As we learn in analytical geometry, one means of distinguishing between conic sections is by means of their eccentricity. If e is the

eccentricity, we may classify the conics as follows:

A circle if e = 0
An ellipse if 0 < e <1
A parabola if e = 1
A hyperbola if e > 1

The following drawing should be studied carefully, as we shall refer to it several times in the activities discussed below.



Let S be the location of a satellite in an elliptical orbit about a primary body with center at F, a focus of the ellipse. The semi-major axis of the ellipse is a, and the major axis is 2a. The eccentricity of the ellipse is

$$e = \frac{c}{a} .$$

It can be seen from this equation that if c = 0, e = 0. Referring to the drawing, we note that if c = 0, the point F coincides with O, and the ellipse degenerates into a circle. However if $c \longrightarrow a$, the point F moves toward C, the eccentricity approaches unity, and the ellipse becomes "narrow" and "stretched out." Thus the eccentricity is a measure of the roundness of the ellipse.

Below is the general two-body formula for the velocity of a satellite in orbit about its primary:

$$v = \sqrt{GM\left(\frac{2}{r} - \frac{1}{a}\right)}$$

In this formula, G and M have the same meaning as before, a is the semi-major axis of the ellipse, and r is the "radial" distance of the satellite from the center of its primary at F. If r = a, the ellipse becomes a circle (with eccentricity zero), and the formula reduces to the familiar one for circular orbital velocity,

$$v = \sqrt{\frac{GM}{r}} .$$

When the eccentricity becomes unity, the ellipse opens out to become a parabola, the second focus is at infinity, and the value of a becomes infinitely large. The ratio $\frac{1}{a} \rightarrow 0$, and the equation reduces to

$$v = \sqrt{\frac{2\,GM}{r}} .$$

This equation may be rewritten as

$$v = \sqrt{2}\ \sqrt{\frac{GM}{r}} .$$

Thus the velocity needed to achieve a parabolic or escape orbit is easily obtained by multiplying the circular orbital velocity by $\sqrt{2}$ or by approximately 1.41. If the velocity imparted to the satellite is greater than this, the satellite simply follows a hyperbolic orbit, and the eccentricity is greater than one. It will be noted that the escape velocity needed depends upon the altitude, and becomes less as the altitude increases.

a. Students have previously found circular orbital velocities about several different primary bodies at several altitudes. Have them multiply these by $\sqrt{2}$ and find the minimum escape velocities from these altitudes.
b. It is planned for a launch vehicle to give a body escape velocity from the earth. The last stage of the launch vehicle burns out and separates from the satellite at an altitude of 80 miles. What is the minimum velocity that it must impart to the satellite?

In previous problems the student has computed surface orbital velocity (altitude 0 miles) about several bodies in the solar system. It may have seemed foolish to do this computation, since surface orbits are impossible. No body is smooth, and the presence of any atmosphere would quickly reduce velocity. However these computations enable us to find the escape velocity at the surface of these bodies. The value of the escape velocity is a major factor in determining the environment at the surface of the body. If the escape velocity is small, molecules of gas at the surface will move with velocities greater than escape velocity and will soon escape into space. Thus the moon has no atmosphere. On the other hand Jupiter with its high escape velocity holds a dense atmosphere, probably 1000 miles deep, with pressure at the surface great enough to crush an earth man.

c. Have students compute the surface escape velocities of the earth, moon, Mars, Venus, Jupiter, and the sun, using the circular orbit velocities previously computed.

4. We can say with confidence that all closed orbits are actually ellipses. Even if a circular orbit is desired, there will always be a slight deviation from the circular path, since it is impossible for a launch vehicle to impart the exact velocity needed. There is always an error, however small. Thus the velocity which we obtain from using the formula for circular orbital velocity is actually an average of the velocities at apogee and perigee. Furthermore in many applications an elliptical orbit is more desirable. It is therefore necessary that we give some attention to the mathematics of elliptical orbits.

In order to analyze an elliptical orbit, we must usually know its eccentricity. The eccentricity can easily be found if we know the apogee and perigee distances. These distances are customarily published in news reports of orbiting spacecraft. Perigee is the point at which the satellite has the lowest altitude, while apogee is the point of greatest altitude. Press reports ordinarily give these distances in miles above the surface. However the mathematics is much simpler if the perigee and apogee distances are given from the center of the primary body. In the case of the earth, we merely add to the altitudes for perigee and apogee the radius of the earth, 3960 miles.

In the drawing previously discussed, the apogee and perigee distances from the center of the primary body are indicated by A and P respectively. The following relationships are readily apparent from the drawing.

$$a = 1/2\,(A + P)$$

$$c = a - P = 1/2\,(A + P) - P = 1/2\,(A - P)$$

$$e = \frac{c}{a} = \frac{1/2\,(A - P)}{1/2\,(A + P)} = \frac{A - P}{A + P}$$

The following table will be useful in working a group of problems.

Orbiting Body	Perigee Altitude (miles)	Apogee Altitude (miles)
Sputnik I	132	583
Explorer I	220	1,580
Echo I	950	1,050
Gemini V	101	217
Explorer XIV	175	61,000
Nimbus I	252	578
Orbiting Solar Observatory II	394	432
Earth (about sun)	91,400,000	94,600,000
Lunar Orbiter II (about moon)	27	1,167

a. Compute the eccentricity for each of the above bodies. (For Sputnik I, P = 3960 + 132 = 4092; A = 3960 + 583 = 4543;

$$e = \frac{4543 - 4092}{4543 + 4092} = \frac{451}{8653}$$

$$= .052.)$$

b. Find the eccentricity of the earth's orbit about the sun. Note that the orbit is nearly circular.

c. Compute the eccentricity of any body when A = P.

5. Actual formulas for perigee and apogee velocities can be obtained easily from the general two-body formula,

$$v = \sqrt{GM\,(\frac{2}{r} - \frac{1}{a})}\,.$$

If we refer to the drawing in part 3, we obtain the following relationships. Since $e = \frac{c}{a}$, c=ea. But A = c + a = ea + a = a(1 + e). From this equation we get $\frac{1}{a} = \frac{1+e}{A}$. Obviously at apogee r = A. Let v_A = the velocity at apogee. Then substituting these values in the two-body formula, we obtain

$$v_A = \sqrt{GM\,(\frac{2}{A} - \frac{1+e}{A})}\,,$$

which simplifies to

$$v_A = \sqrt{\frac{GM}{A}\,(1 - e)}\,.$$

Similarily we may derive a formula for v_P, the velocity at perigee. In the drawing, P = a - c = a - ea = a(1 - e). Then $\frac{1}{a} = \frac{1-e}{P}$ Substituting in the two-body formula yields

$$v_P = \sqrt{GM\,(\frac{2}{P} - \frac{1-e}{P})},$$

which simplifies to

$$v_P = \sqrt{\frac{GM}{P}\,(1 + e)}\,.$$

a. A spacecraft in orbit about the earth has apogee and perigee altitudes of 1000 miles and 500 miles respectively. Find the respective velocities.

(Solution: e= .053.

$$v_P = \sqrt{\frac{9.56\ (10)^4}{4460}\ (1.053)} = \sqrt{22.5}$$

= 4.74 miles per second or 17,100 miles per hour.

$$v_A = \sqrt{\frac{9.56\ (10)^4}{4960}\ (.947)} = \sqrt{18.2}$$

= 4.27 miles per second or 15,400 miles per hour.)

b. The greatest and farthest orbital distances with reference to the moon are often called apolune and perilune, rather than apogee and perigee. Suppose the spacecraft above is orbiting the moon with perilune and apolune of 500 miles and 1000 miles respectively. Find the two velocities. (Remember that for the moon, GM = 9.56 $(10)^4$ (.012), and r = 1080. v_p = 3280 miles per hour, while v_A = 2480 miles per hour.)

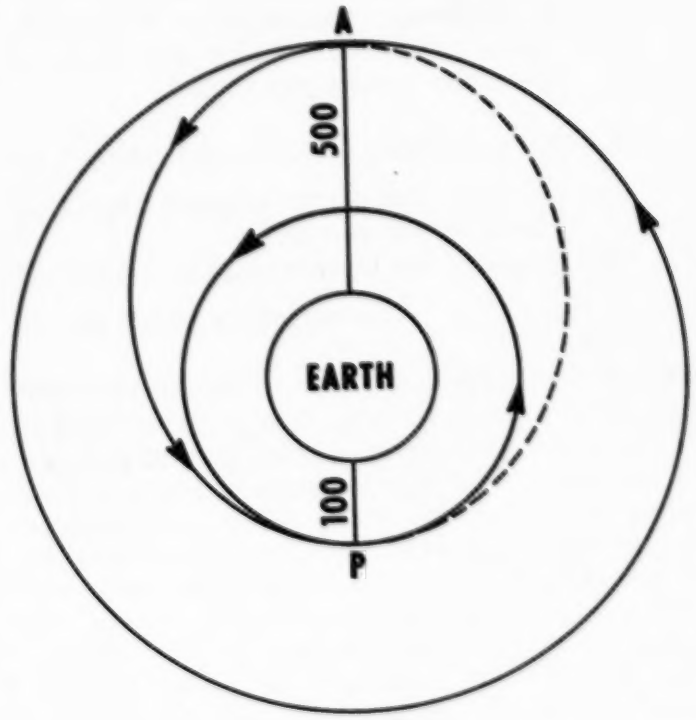
c. Find the velocities at perigee and apogee of several of the spacecraft for which orbital elements were given in Part 4 above.

d. Lunar Orbiter I was placed in an orbit about the moon with apolune of 1,148 miles and perilune of 133 miles. Find its velocity at these points. It was desired to retain the same apolune but to reduce the perilune to 36 miles. Find the velocities in the new orbit. A change of this type in the orbit would be made at apolune, and would be achieved, as the student's mathematics should show, by slowing the spacecraft with a retrograde burn. Find the reduction in velocity needed.

6. Being able to find circular, apogee, and perigee orbital velocities will enable us to solve many interesting problems related to the changing or modifying of orbits. When one of the syncoms (synchronous satellites) was launched, it was injected into an elliptical orbit, and it gradually slowed as it rose. When it reached the desired altitude of 22,300 miles, its speed was down to 4800 feet per second or about 3270 miles per hour. But circular orbital velocity at that altitude is, as we have previously computed, about 6880 miles per hour. Therefore an apogee motor on board the spacecraft was fired to increase its velocity by 6880 - 3270 or 3610 miles per hour. If the weight of the spacecraft and the thrust of the motor are known, one can compute the number of seconds that the motor must fire to achieve this increase in velocity. The signals to start and stop the firing are radioed to the spacecraft from earth. (The formula needed is found in Part 5 of Topic 7.21.)

a. In a previous problem we computed the velocities at perigee and apogee of 500 miles and 1000 miles respectively above the surface of the earth. What additional velocity must be imparted at apogee to circularize the orbit? If the satellite weighs 500 pounds and the thrust of the motor is 100 pounds, how long must the motor be fired?

b. Let us assume that a Gemini spacecraft weighing about 7000 pounds is in a circular orbit 500 miles above the surface of the earth. It is desired to lower the orbit to a circular path 100 miles above the surface. The most efficient method of orbital change is to use a Hohmann transfer, as pictured in the following diagram.



When the spacecraft is at A, it is slowed by a retrofire to make it fall into an elliptical orbit with perigee P of 100 miles. If it is not further slowed at P, it will climb back to apogee at A. Therefore it must be slowed again at P so that its velocity is reduced to circular orbital velocity at 100 miles altitude. If we can compute the

circular and elliptical velocities at the points A and P, we can easily find the changes in velocity needed. If the spacecraft has retro motors giving a total thrust of 600 pounds, we can compute the thrusting times needed to produce the desired reductions in velocity. Compute the data for this problem.

c. Using the data given in the table for Part 4 above, find the change in velocity needed to circularize the orbit of Explorer 1 at perigee. At apogee. Work similar problems for some of the other spacecraft listed.

d. Have students compute the ratio $\frac{v_A}{v_P}$ by dividing the first velocity equation above by the second.

7. The result of the above computation should be $\frac{v_A}{v_P} = \frac{P}{A}$. This equation states one of the important consequences of Kepler's Second Law of Planetary Motion. It says in words that the ratio of the velocities at apogee and perigee is the reciprocal of the ratio of perigee distance to apogee distance. (This law could be derived by geometric methods from a drawing illustrating the fact that a line from the satellite to the center of its primary sweeps out equal areas in equal times.) In other words, the satellite is traveling at its lowest velocity when it is at apogee and at its greatest velocity when it is at perigee.

a. Find the ratio of perigee distance to apogee distance, if the perigee velocity is three times the apogee velocity; n times the apogee velocity.

b. Could the apogee velocity ever be greater than the perigee velocity?

c. Under what circumstances are the apogee and perigee velocities equal? What is the eccentricity of the ellipse?

TOPIC 7.21

Problem Solving

LEARNING ACTIVITIES

(10-12)

1. Show that the force of gravity and the acceleration of gravity are one-sixth as great on the moon as on the earth.
2. Find the location of the neutral gravitational point between the moon and the earth. Between the sun and the earth.
3. Compute the altitude at which the period of a satellite will be 24 hours.
4. Find what percent of the earth's surface can be "seen" from the altitude computed above.
5. Compute the velocity that a body will reach if a given thrust acts on it for a given time.
6. Compute the rate of rotation needed to produce a given artificial gravity in an orbiting spacecraft.

REINFORCEMENT

1. Newton's Law of Universal Gravitation says that

$$F = \frac{GMm}{r^2} ,$$

where G is the constant of universal gravitation, M and m are the masses of the two bodies with which we are concerned, F is the force of attraction between them, and r is the distance between their centers of gravity. For a spherical body of uniform density, the center of gravity is at the center of the sphere. (G should not be confused with g, the acceleration produced by gravity, which near the surface of the earth is 32.2 feet per second during each second.)

If F_e is the attraction between the earth and a body of mass m on its surface,

$$F_e = \frac{GMm}{(3960)^2} .$$

Similarly, let F_m be the attraction between the moon and the same body of mass m lying on its surface. The mass of the moon is .012 times the mass M of the earth. Therefore

$$F_m = \frac{G\,(.012\ M)\ m}{(1080)^2} .$$

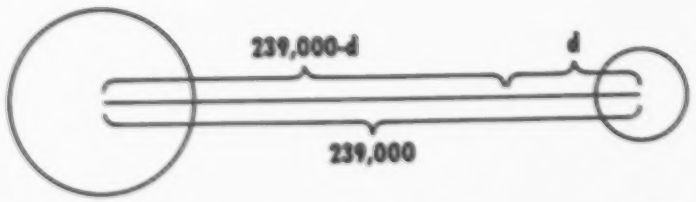
a. Have students write the ratio $\frac{F_m}{F_e}$ and simplify. It should reduce to almost precisely 1/6.

According to Newton's Second Law of Motion, the acceleration produced by a force is directly proportional to the force. Therefore the acceleration produced by the moon's gravity is

$\frac{32.2}{6} = 5.4$ feet per second per second.

b. The number of feet that an object will fall in t seconds is given by the equation $s = 1/2\ at^2$. At the surface of the earth, $a = g = 32.2$, while at the surface of the moon $a = 5.4$. Compare the distances that objects will fall on earth and on the moon for times of 1 second, 5 seconds, 10 seconds, 1 minute.

c. Have students make up problems like those given in the section for Grades 7 - 9 involving the acceleration of elevators in office buildings on the moon.



2. At a certain point between the earth and the moon, the gravity "pulls" of the two bodies will be equal. At this neutral point, if we neglect the gravity forces of the sun, planets, and other bodies, an object would be physically weightless. Let us suppose that a body of mass m is located at this point. The attraction between the body and the earth is

$$F_e = \frac{GMm}{(239{,}000 - d)^2} .$$

Let us express the attraction between the body and the moon as

$$F_m = \frac{G\frac{M}{81}m}{d^2} = \frac{GMm}{81\,d^2} .$$

(Since the more precise value of .0123M for the mass of the moon is very nearly equal to $\frac{M}{81}$, this arrangement is valid, and it greatly simplifies the computation.)

a. Have the students set $F_e = F_m$, and solve the equation for d. (d = 23,900 miles, making the neutral point 9/10 of the distance from the center of the earth.)

b. The mass of the sun is 330,000 times the mass of the earth. Find the neutral gravitational point between the sun and the earth. (The distance is 162,000 miles from the center of the earth. Since the moon gets beyond this distance, some students may wish to find out why the moon is not captured by the sun.)

3. If a satellite with a period of 24 hours is moving east in an orbit over the equator, it will remain constantly over a point on the earth below it and will appear to an observer on earth to be stationary. Since its period is synchronized with the rotation of the earth, it is called a "synchronous" satellite. Syncom, Early Bird, and other synchronous satellites are in such orbits.

If we are to compute the altitude that will make a satellite's motion synchronous with the rotation of the earth, we must find a way to relate its period to its velocity. The distance traveled during one revolution will be $2\pi r$, and this distance is traveled during time t. The velocity is then $v = \frac{2\pi r}{t}$. But the velocity in miles per second of a satellite in a circular orbit is

$$v = \sqrt{\frac{9.56\,(10)^4}{r}} ,$$

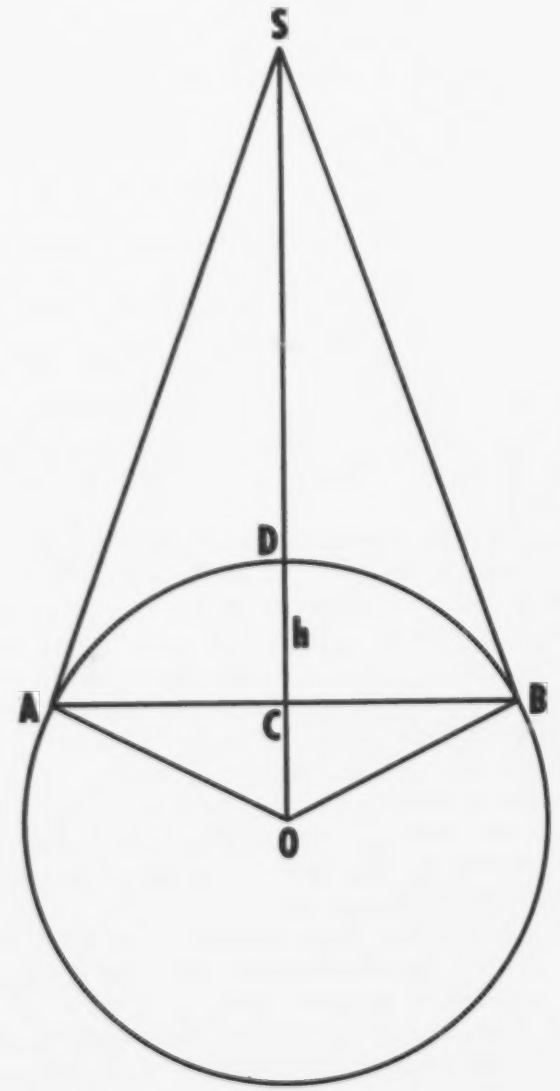
as explained in the previous discussion of conic sections. Eliminating v yields

$$\frac{2\pi r}{t} = \sqrt{\frac{9.56\,(10)^4}{r}} .$$

a. The student should solve this equation for r. (Remember that the units are miles and seconds, and therefore the value of t = 24(3600), the number of seconds in 24 hours. Squaring and solving will readily give us a value for r in miles from the center of the earth. Subtracting the radius, 3960, will give the altitude above the surface. The correct answer is 22,300 miles.)

4. The area seen by the satellite at S is the area of a zone with altitude CD = h. DS = 22,300, and AO = OB = 3960.

a. Have students solve for h by using similar triangles. They can then readily find the area of the zone and the percent that it includes of the earth's surface.



5. According to Newton, the acceleration produced by a force is directly proportional to the force. Therefore $\frac{f}{a}$ is a constant. We can obtain a second pair of values by letting a body fall near the surface of the earth. Then the force is the weight w of the body, and the acceleration produced is g, the acceleration of gravity, equal to 32.2 feet per second during each second. Therefore $\frac{f}{a} = \frac{w}{g}$, from which we obtain $a = \frac{fg}{w}$. Since acceleration is change in velocity per unit of time, $a = \frac{v}{t}$, and therefore $v = at$. Combining these two equations yields $v = at = \frac{fgt}{w}$. If f is the thrusting force in pounds, and w is the weight of the body in pounds, then v is the velocity in feet per second attained if the thrusting force acts for t seconds.

It should be noted that this equation ignores the retarding effects of gravity and air resistance, and the effects of other perturbing forces. Thus if a spacecraft has been placed in a parking orbit about the earth and a low-thrust engine is turned on, the gain in velocity will be less than the equation predicts because the thrust has to overcome gravity, as well as inertia. But when the spacecraft has reached a point far enough from the earth that the gravity force is very weak, the above equation will give realistic answers.

a. A 150-ton spacecraft is on a trajectory far from the earth. An ion propulsion engine with a thrust of 50 pounds is turned on. What will be the increase in velocity in 7 days? In 30 days?

The Gemini spacecraft used four solid-propellant retrorockets with a thrust of 2500 pounds each. They were ripple fired (with overlapping burning times) to slow down the spacecraft so that it began to re-enter the atmosphere. On one of the flights, the weight of the spacecraft at retrofire was 5440 pounds, and the reduction in velocity achieved was 335 feet per second.

b. Using the formula above, have students compute the total firing time needed to achieve this reduction in velocity. Assume that the four 2500-pound thrust motors were fired in sequence. One-fourth of the total time would be the burning time for each motor. However, the total elapsed burning time was 21.8 seconds, less than the computation will give. Have the students compute the amount of overlap. (Burning times were 5.66 seconds, with overlaps of .28 seconds.)

6. One way of overcoming the "weightless" condition which exists in an orbiting spacecraft is to create an artificial gravity by rotating the spacecraft. When a body is moving in a circular path, it has a constant acceleration toward the center, expressed by the equation $a = \frac{v^2}{r}$. If a person is standing inside a rotating spacecraft, the side of the spacecraft, since it is accelerating toward the center, gives the astronaut a constant push toward the center. The reaction of his body is to push against the side, so that he feels as though he were in a gravity field.

The velocity of a point on the side of the rotating spacecraft is $v = (2\pi r)N$, where v is the velocity in feet per second, r is the radius in feet at the point of revolution, and N is the number of revolutions per second.

a. Have students substitute this value of v in the equation for central acceleration above, and solve for N. (They should obtain

$$N = \frac{1}{2\pi}\sqrt{\frac{a}{r}}.$$

N is the number of rotations per second, and 60N will be the number per minute.)

In the above equation, a is the value of artificial gravity in feet per second per second. The spacecraft rotation will probably be controlled by the use of thrusters located on the outer rim. By controlling the value of N, the astronauts can tailor the artificial gravity to meet whatever needs exist.

b. An early design for orbiting space stations suggested that they be built in the form of a hollow closed tube, like an automobile inner tube. Suppose that the outside diameter of such a station is 1000 feet. Then the radius from the center of rotation is 500 feet. If the artificial gravity is to equal earth gravity, $a = 32.2$; if it is to equal half of earth gravity, $a = 16.1$. Have students compute the number of rotations per minute needed to create various values of artificial gravity for space stations of various sizes. (If $r = 500$ feet and $a = 32.2$, $N = 2.42$ rotations per minute.)

TOPIC 7.22

Logarithms

LEARNING ACTIVITIES

(10-12)

1. Study a formula for finding the final (burnout) velocity of a stage of a launch vehicle.
2. Use the formula to find the velocity imparted to the Apollo Spacecraft by the Saturn V.
3. Use the formula to find the respective velocities of the stages of an interplanetary spacecraft.

REINFORCEMENT

1. The final or maximum velocity attained by a stage of a launch vehicle is given by a simple formula: $v = c \log_e R$. Since the maximum velocity is achieved when the fuel or propellant has all been burned, this is often termed the burnout velocity. R is the mass ratio, which is the ratio of the total initial weight to the weight remaining after the fuel in the stage has been all burned. Note that the formula uses natural logarithms (base e).

We can easily compute the velocity of the exhaust gases if we know the specific impulse of the fuel. Specific impulse, I_{sp}, shows the relationship of the thrust produced to the rate of use of propellant, and is therefore like miles per gallon. We find it by dividing the thrust, f, in pounds produced, by the weight, w, in pounds of propellant burned in t seconds, so that $I_{sp} = \frac{f}{w/t}$. When the equation is applied in an actual example, we think of pounds of thrust in the numerator cancelling pounds of propellant in the denominator, leaving the answer in seconds. Thus a propellant with a specific impulse of 300 seconds will provide a thrust of 300 pounds if one pound weight of the propellant is burned in one second. Obviously the specific impulse of a given fuel depends both upon the characteristics of the fuel and the efficiency of the engine in which it is burned. The exhaust velocity c is found from the equation $c = g\, I_{sp}$, where g is the acceleration of gravity, or 32.2. Those who wish to verify this equation can find the derivation in the standard elementary literature on propulsion. Exhaust velocity will vary somewhat with altitude. At low altitudes the flow of the exhaust molecules is impeded by the relatively dense air. In the vacuum above the atmosphere, the exhaust velocity, and therefore the specific impulse, becomes greater.

Since R is the ratio of the weight of the structure and propellant to the weight of the structure alone (after the propellant has all been burned), it is clear that there are practical limits to the value of R. Suppose that a launch vehicle is composed of nine parts propellant and one part structure. Then

$$R = \frac{9 + 1}{1} = 10.$$

This is about the highest mass ratio possible at the present time. If more propellant is added but the weight of the structure remains the same, the structure may be too fragile to support the weight of the propellant, and the vehicle will collapse under the stresses of operation.

Let us compute the burnout velocity of a launch vehicle with $R = 10$ and $I_{sp} = 300$ seconds average. We obtain $v = (32.2)(300) \log_e 10 = 9660 \times 2.30 = 22{,}200$ feet per second. The vehicle will not in practice reach this speed. The speed will be reduced by the pull of gravity and will be further retarded by friction with the rather dense lower atmosphere. The gravity and air drag depend upon various factors such as the time and angle of flight during the burning period and the configuration and altitude of the vehicle. However we can get estimates of the total drag from tables that have been compiled from experience. In the case of this vehicle, the total drag might be about 4,000 feet per second, leaving a net speed of 22,200 - 4,000 = 18,200 feet per second or 12,400 miles per hour. This speed is too low to put a satellite into orbit.

2. The above problem illustrates the advantage of dividing a launch vehicle into stages, so that the dead weight in each stage will be dropped away after its propellant has been burned. The Saturn V, the vehicle developed to put men on the moon, has three main stages. Its original design gave it a make-up approximately as follows: First Stage--structure 150 tons, propellant 2200 tons of liquid oxygen and kerosene, with $I_{sp} = 286$ seconds; Second Stage --structure 44 tons, propellant 456 tons of liquid oxygen and liquid hydrogen, with $I_{sp} = 420$ seconds in a vacuum (the vehicle will be above most of the atmosphere after burnout of the first stage); Third Stage--structure 10 tons, propellant 115 tons of liquid oxygen and hydrogen, $I_{sp} = 420$ seconds; payload (Apollo Spacecraft) 45 tons. The total air and gravity drag will be about 6,400 feet per second.

Since the first stage must lift the structure and propellant of the remaining stages, as well as the payload, the mass ratio of the first stage is the total takeoff weight divided by the weight remaining after the first-stage propellant has all been burned.

a. Find the total burnout velocity of Saturn V.

$$R_1 = \frac{2200+150+456+44+115+10+45}{150+456+44+115+10+45}$$

$$= \frac{3020}{820} = 3.68$$

Similarly $R_2 = \frac{670}{214} = 3.13$, and

$$R_3 = \frac{170}{55} = 3.09.$$

Therefore

$$v = (286)(32.2)\log_e 3.68 + (420)(32.2)\log_e 3.13 + (420)(32.2)\log_e 3.09$$
$$= 42{,}600 \text{ feet per second.}$$

Subtracting the drag losses gives a net speed of about 36,200 feet per second, or 24,700 miles per hour.)

b. Will the velocity of the Apollo Spacecraft take it to the moon? (From the previous discussion in this section, the student can compute that at an altitude of 100 miles the escape velocity is about 24,700 miles per hour. Thus the payload has velocity to go to the moon and beyond. However full escape velocity is not needed, since the Apollo Spacecraft needs to be propelled only beyond the neutral gravitational point, 23,900 miles from the moon. Beyond this point, the moon's gravity would pull it in. However the use of full escape velocity considerably shortens the travel time. A retro (reverse) thrust will be used to slow the Apollo Spacecraft as it reaches the moon in order that it may go into lunar orbit.)

3. Within a decade manned spacecraft will undoubtedly be used to send men to the nearer planets. Nuclear engines will heat liquid hydrogen to high temperatures and expel the molecules at high velocity, producing a large and long-lasting thrust. The following interplanetary spacecraft is too heavy for takeoff from the earth's surface. A number of Saturn V's will be used to lift the parts into an earth orbit of 100 or 200 miles, where they will be assembled in space. Losses from air drag will not exist because the interplanetary vehicle will begin its flight above the atmosphere. Because of its high thrust, gravity losses can also be ignored. The spacecraft is constructed as follows: First Stage--structure 158,000 pounds, propellant 530,000 pounds; Second Stage--structure 69,000 pounds, propellant 228,000 pounds, Mars Excursion Module (to be discarded in Mars orbit) 150,000 pounds; Third Stage--structure 49,000 pounds, propellant 164,000 pounds, Mission Module 100,000 pounds, Earth Return Module 20,000 pounds. Isp = 850 seconds for each stage.

In the case of this vehicle, the separate velocities do not add. The first stage velocity will propel the craft to Mars, the craft will then be turned around so that the second stage thrust reduces the velocity to enable the ship to go into Mars orbit (Mars Excursion Module is discarded and left in orbit), and the third stage velocity will propel the Mission Module and Earth Return Module back to earth.

a. Find the velocities of the respective stages.

$$(R_1 = \frac{1{,}468{,}000}{938{,}000} = 1.562,$$

$$R_2 = \frac{780{,}000}{552{,}000} = 1.415,$$

$$R_3 = \frac{333{,}000}{169{,}000} = 1.970$$

$v_1 = (32.2)(850)\log_e 1.562 = 12{,}200$ feet per second or 8320 miles per hour, $v_2 = 9{,}510$ feet per second or 6480 miles per hour, $v_3 = 18{,}600$ feet per second or 12,700 miles per hour. Since this spacecraft is assembled in orbit, it will have a velocity before it begins operation of nearly 17,500 miles per hour relative to a point on earth. Thus its total velocity relative to earth as it begins its journey to Mars will be 17,500 + 8,320 or about 25,800 miles per hour. This velocity is considerably above minimum escape velocity.)

8. Industrial Arts

by Gerald P. Antonellis

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Industrial Arts

INTRODUCTION

The world of work has become increasingly more complex with the advent of the Space Age. If one subscribes to the premise that Industrial Arts is in part the introduction to todays complex industrial life then the Aerospace Industry must be included as a part of this introduction. In order to approach this industry we must first lift the lid of astronauts, large launch vehicles, satellites and the other news provoking items and get to the bottom of the pot - to the basic worker - to the processes, materials, machines, tools and principles and the significance of the new technology as it effects our way of life.

Only a small part of the Aerospace Industry is visible to the public, but like the iceberg, below the surface is a complex of manpower from government, industry and university numbering at the present time over a million workers. The effort to launch a space vehicle is undergirded by an array of industrial companies in almost every state of our union and in occupational areas ranging from electronics to food packaging and preparation, from ceramics to graphics, from metals to wood products.

Although the end product of our National Space Program is new knowledge and the tools used to obtain this knowledge are unusual and esoteric in nature, the research, development, construction and operation of these tools utilizes fundamental skills long used in our industrial complex. The greatest challenge to the aerospace industry is quality--every nut, bolt, switch, structure, etc., must meet the requirements of doing its job in the hostile environment of space one hundred per cent of the time. As a by-product of this challenge, our educators must accept the challenge of producing students well grounded in fundamentals and capable of growth and flexibility to keep up with the ever-expanding horizons of the Space Age.

Basic concepts are not often discussed in teaching of Industrial Arts. The emphasis has been on skills. Yet each of the skills is built on concepts as well as on understanding, values and habits that will for many students endure long into their working life.

We study industry and refer to it as the production of services and goods. However, it must be remembered that in the Research and Development industries the end product is knowledge, new knowledge that must be then interpreted and applied back to the industry in a closed loop. Even though Industrial Arts is primarily concerned with goods and products, the fact that a large part of US industry is now involved with research and development must be kept in mind. Many industries do not produce a product over and over again, but instead produce a few items and then move on to other new products.

In all of these, we start with an idea and carry it through to production of a consumer good. The elements of industry are the same whether you are producing thousands of cars or a dozen Apollo capsules.

Abstract thinking must be enhanced by manipulation and visualization through involvement in order to better motivate our young people. Industrial Arts offers this kind of activity and has proven to be an effective tool for teaching.

At the lower elementary level, Industrial Arts is a unique tool for student involvement in experiences related to the language arts, science, mathematics and social sciences. The teacher needs only the imagination and creativity necessary to relate manipulative and visual experiences to the existing courses of study. Hopefully, the ideas presented here will be of assistance in starting the process.

At the upper elementary level, Industrial Arts can become a direct curriculum offering that would necessitate special preparation on the part of the teacher and as well as specially designed facilities. Where these exist, the study of industry and its role in our lives can take on the activities of planning, designing and constructing as they relate to the overall curriculum. However, if no facilities are available and the teacher not specifically trained in Industrial Arts, the process indicated for the lower elementary level can be extended into the upper elementary levels as an integrated part of the curriculum. The attributes of Industrial Arts as a teaching tool with its emphasis on involvement offer a motivational tool which should not be overlooked.

At the secondary level the fully equipped shop becomes available as well as the trained teacher. The trend is away from the pure shop experience and toward a study of industry and more relationship to the total curriculum. Here the student can experience the process, procedures and practices of industry and the Space Program can provide a motivational tool around which many teaching units can be built.

ELEMENTARY INDUSTRIAL ARTS

(K-3)

To watch a child in his formative years we observe that he learns through his senses. He looks, smells, touches, tastes and listens, involving himself thoroughly in his surroundings. The world he lives in is full of "new and exciting things." This inquisitiveness should be fostered as he grows and should not be regulated to a textbook frame of reference that retards this discovery process of learning.

General Objectives

1. To acquire knowledge of materials (substance) and industrial processes and problems.
2. To learn to set their ideas to paper (plans) and to follow this plan to completion.
3. To develop manual dexterity through tool manipulation.
4. To develop a degree of proficiency in use of tools individually and in a team effort.
5. To develop attitudes and work habits.

In developing concepts in tool and machine use, technical terms can be used in the elementary grades but there is little advantage derived from a complex development of these terms as concepts. Rather the example of the term should suffice at this level. Mechanical advantage of gears need only be demonstrated as opposed to teaching a 5-1 gear ratio. Autos faster than bicycles, etc.

TOPIC 8.01

Space Travel:

Man, like birds, has gained the power of flight.

LEARNING ACTIVITIES

(K-3)

1. Show and tell activities based around observations of flight which have arisen out of social science and science activities and readings. Concerned here are the observable difference in flight: Natural - birds, insects, etc.; Man-made - rockets, planes, gliders, etc.
2. In dealing with family studies, discuss any aerospace occupations in class. Again, remaining in the unit of technology, discuss the observable prop planes, jets, rockets. Simple elastic-driven planes as opposed to gliders for mechanical power vs. reliance on winds, etc., will serve as an example.

1. Using paper of varying weights:
   a. Fold back paper (swept-back wing)
   b. Put to flight
      (1) Check height of flight
      (2) Check for distance of glide path.
2. Simple two-dimensional push-outs (rockets, etc.). Assemble, show, and tell.

REINFORCEMENT

1. Use small round, long slim, long irregular balloons to demonstrate propulsion.
2. Put fins on balloons and set them to flight.
3. Place balloons in wheel-operated vehicles and drive them across the floor or out in the yard.
4. Construct a light-weight, two-dimensional plane and propel it with a balloon.

TOPIC 8.02

Technological advance:

(K-3)

Technology assists Man in satisfying his needs. (Source: Social science concept.) Man constantly seeks new ways to control his environment and to satisfy his needs.

LEARNING ACTIVITIES

1. Discuss planes: where manufactured throughout country; in Massachusetts.
2. Draw two-dimensional plane. Get them balsa wood and glue pattern to wood and cut out.
3. Assemble.
4. Fly.
5. Check for height.
6. Check for distance of glide.
7. Examine design.
8. Briefly explain principles of flight.
9. Design another and follow same procedure.

REINFORCEMENT

1. Visit a local air field.
2. Design bi-planes, simple two-dimensional.
3. Add simple dihedral for finishing and smoother flight pattern.

TOPIC 8.03

Man as a tool user (K-3)

Man's utilization of tools assists him in advancing his goals. (NASA's concept "if man aspires to goals, etc.").

LEARNING ACTIVITIES

In developing this unit refer to items 2 and 3 in introduction.

1. Build sit-in model-plane.
2. Discuss principle of control.
3. Form crews to construct plane.

(Simple media - a few pieces of lumber, a few nails, some rubber or canvas or leather from old boots or shoes to act as hinges for ailerons and rudder. An old fan to serve as prop motor.)

REINFORCEMENT

1. Plan and build an Apollo Space Capsule (plan and obtain simple materials needed: pg 15 -18 "Introducing Children to Space").
2. Discuss problems of structure relative to living in space.

Children love to build things and would take special delight in being able to construct a crude plane to simulate flight.

TOPIC 8.04

Interdependence. (4-6)

Aerospace activities are dependent upon cooperative effort of many divergent industries and technological skills.

Improved transportation facilities, faster communication and American competitive spirit cause many changes and develop many occupations to shape our way of life.

List of Industries in Massachusetts:

1. Fabricated metals
2. Machinery
3. Stone, clay and glass
4. Ordinance
5. Electronics
6. Instruments
7. Space
8. Paper
9. Printing & Publishing
10. Transportation
11. Utilities
12. Chemicals
13. Rubber & Plastics
14. Textiles
15. Apparel
16. Shoes & Leather
17. Furniture
18. Food
19. Jewelry
20. Research & Development
    a. recreation
    b. sports equipment
    c. musical instruments
    d. lumber and wood products
    e. petroleum
    f. miscellaneous (games, etc.)

LEARNING ACTIVITIES

1. Field Trips
2. Discuss employment of heads of families, relate to NASA, etc.
3. Skill work - hand tools vs. mass production (problem of quality control)

Two dimensional plane, mass produced in one class and individually made in another.
4. Relate list of Massachusetts industries to space industry.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space the New Frontier
EP-31	Space Jobs
EP-34	NASA Astronauts
EP-36	Introducing Children to Space
EP-45	Fifty Years of Aeronautical Research
NF-8	Launch Vehicles
NF-9	Manned Space Flight (Mercury-Gemini)
NF-20	U.S. Launch Vehicles for Peaceful Exploration of Space
NF-21	V/Stol Aircraft
NF-23	Manned Space Flight (Apollo)
NF-27	Living in Space
NF-34	Lifting Bodies

TOPIC 8.05 (4-6)

Wheels, Gears, Cars, Pulleys, Linkages, etc. are machines.

If we study principles underlying motion and mechanics and their application in a generalized form the young student can obtain these general objectives.

1. an understanding and insight into the basic principles which are involved in and underly motion and "the world at work".
2. to provide a problem solving experience through reflective thinking where the student may be creative in expressing his talents.
3. to provide experiences relative to industry where the students acquire technical data, a familiarization with inventions and great cultural advances.

4. a consciousness of the value of scientific method in the analyzing and solving problems in daily life as well as the industrial arts lab.
5. a consciousness of the importance of design and layout as the functioning of technical products.
6. a consciousness of the processes involved in experimental and developmental industries of this technological age.
7. a consciousness of the tools used in these experimental and developmental industries.
8. an insight into occupations, products and industries which are involved in experimental and developmental industries of this technological age.
9. a development of a hunger for knowledge especially about new developments in space.

LEARNING ACTIVITIES

(4-6)

1. Develop a time line based on man's speed, from walking to rocket travel. Build models of the various machines that have increased our speed: man, rail, horse and wagon, sailboat, steam engine (railroad or boat)automobile, airplane (propellor and jet), and rocket vehicle.
2. Discuss interrelation of power development and man's way of life--his occupations.
3. Develop and build a display of the above materials. Work as a group in planning and assigning tasks.

REFERENCES AND RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space the New Frontier
EP-32	Learning about Space Careers
EP-36	Introducing Children to Space
NF-8	Launch Vehicles
NF-20	U.S. Launch Vehicles for Peaceful Exploration of Space (Color supplement to NF-8)
NF-34	Lifting Bodies

TOPIC 8.06

From Cubit to Micrometer. How to teach a beginning drafting student to read a rule from interest:

LEARNING ACTIVITIES

(7-9)

We should teach a beginning Junior High School drafting student how to read a rule or scale from interest. One of these first interest stories may be about "David and Goliath". Every boy has heard the story of David and Goliath in his home. Goliath a champion out of Gath, whose height was six cubits and a span.

What boy wouldn't be interested in knowing how tall this man would be on a basketball court. Or, the story about the Ark. The length of the Ark was three hundred cubits and the breadth of it fifty cubits and its height at thirty cubits. With these stories and other early stories with interest, generally heard in the home, we may teach how measurement was used before the Christian era. In fact, in 6000 B.C. the first known standard, the cubit, was established in ancient Egypt. The cubit was the distance from the elbow to the tip of the middle finger, roughly about eighteen to nineteen inches. Go to the blackboard and measure the height of the giant by multiplying 6 x 18" and add 9" for a span and you will have 9'9", the student will have some idea of what a giant this warrior was.

With interest developed, the student is ready to listen to why man has always measured the world around him.

Measurement deals with one dimension - inches, feet, yards, miles, etc; two dimensions -square inches, square feet, etc.; three dimensions - quarts, gallons, bushels, cubic inches, cubic feet, etc. This problem of reading a rule or scale is a universal one. The student may learn to read a scale and then shift to the wood shop where trysquares are used, or the metal shop where flat rules are used and seem unable to make the transfer. This may go along with our concept of words in our English language where one word may mean different things according to the individual's experience.

Enlarged scales tend to confuse them because of their concept of size, proportion, and distance.

Practice in measuring 1/4", 1/2", 5/8", and 3/4" on simple problems is a good start on how to read a rule. Smaller measurements and fractions thereof will build confidence and the pupil is on the way to understanding measurement according to the U.S. system of measurement or standard. This is sufficient for the seventh and eighth grade, but the student should know that measurement of millionths and billionths is possible.

TOPIC 8.07

"Man Is The Measure".

Man has always measured the world around him.

Objectives (7-9)

a. To establish a foundation for continuous growth in making layouts, planning, drawing by teaching basic concepts about the

common instruments of drafting and procedures of using them.

b. To acquaint students with terms and concepts which are basic to shop practices, e.g., angle, degree, triangle, square, rectangle, inch, fractional part of an inch, foot, straight edge, layout.

c. To foster the development of ability to visualize shapes, to develop non-verbal appreciation.

d. To start pupils to work, as quickly as possible, while maintaining a policy of making or following a plan.

e. To introduce pupils to the opportunities in industrial arts for designing and making useful and interesting objects.

f. To enlarge the scope of acquaintanceship youngsters may have with desirable playthings.

LEARNING ACTIVITIES

1. Collect and arrange display of two-dimensional planes, including some samples.
2. Collect newspaper and magazine articles about airplanes, rockets, satellites, etc.
3. Collect resource materials from NASA.
4. Select and make, on the drawing board, a two-dimensional plane or space vehicle out of cardboard or paper.
5. Solve the problem of the shape of a plug to fit into the "triangle, circle, and square".
6. Design a plane or space vehicle of your own.
7. Make a stencil, silk screen or common stencil, to reproduce several copies of design- enough for class.

Structures - "Form follows function" (F.L. Wright)

All structure is a struggle between natural forces - gravity, wind, etc. which tend to pull things down or out of shape - through man's ingenuity he constantly finds new methods and materials for holding things together.

Everyone in life is effected by some form of structure whether it be a house that shelters him, a bridge that facilitates transportation, a boat which brings pleasure as well as transportation, a plane which truly expedites and speeds up transportation or a rocket, satellite or spacecraft to venture out to the unknown.

Objectives

1. Knowledge of mechanical properties of materials.
2. How shape effects the strength of materials.
3. Simple stresses and strains.
4. Understanding of simple construction terms.
5. The various methods of bracing used in construction.
6. Knowledge of selecting proper materials for the job to be done.
7. Knowledge in general about building a house, bridge, boat, plane, rocket, space ship, radio towers, support towers for spacecrafts, etc.

LEARNING ACTIVITIES

1. Students prepare a display of suggestions in forms of drawings, prints, pictures, photographs and actual objects which could be made.
2. Each student make an adaptation, redesign, or design; plane, rocket, spacecraft or tower, designed with a specific function and purpose in mind.
3. Collect pictures, illustrations, stories or articles about ventures in space jobs relating to space activities to be kept in scrapbook and put on display on bulletin board.
4. Each student to work on a plane or space project - tower - capsule -rocket, etc.
5. Compile statistics about accidents that happen while working on projects in industry and discuss how they could be minimized or eliminated as a result of consideration of safety and craftsmanship.
6. Collect "how to do" articles from space (NASA) sources.
7. Conduct father and son activity which would involve dad in son's or daughters' activities in industrial arts lab and his space project.
8. Conduct field trips to local air fields and space related industrial plants - (radar structure manufactures, etc.).

REINFORCEMENT

Activities in Industrial Arts labs
Model Building
- a. simple structure for support
- b. flying model of plane
- c. working model of rocket
- d. space communication satellite
- e. launching pad

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-6	Space the New Frontier
EP-33	Seven Steps to a Career in Space Science and Technology
EP-44	Industrial Arts Resource Units
EP-45	Fifty Years of Aeronautical Research
NF-8	Launch Vehicles
NF-20	U.S. Launch Vehicles for Peaceful Exploration of Space (Color supplement for NF-8)
NF-27	Living in Space
SP-7	Dictionary of Technical Terms for Aerospace Use
SP-27	Materials for Space Operations
SP-28	Structures for Space Operations
SP-5013	Precision Tooling Techniques
SP-7012	Constants and Conversion Factors Model Spacecraft Construction The International System of Units

(For information on model rocketry and safe procedures, contact:
National Association of Rocketry
1239 Vermont Avenue, N.W.
Washington, D.C. 20005)

INDUSTRIAL ARTS - HIGH SCHOOL

TOPIC 8.09 **(10-12)**

Exploration

Industrial Arts concern is with the materials of space exploration.

The purpose of this topic is to have the student form generalizations about materials and technology about space exploration.

The students will work with several metal experiments in the technology lab or metal lab that will allow him/her to form useful generalizations about space exploration.

This topic will provide research experience in the tech lab that does not culminate in a project per se; rather it shows the pupil some facets of change in a technological society.

Some generalizations:

1. Exploration is made possible by a society's technology.
2. A society's ability to utilize metal alloys is necessary to successful space exploration.
3. Vehicles of exploration are limited by the utilization of material resources of a technological society.

Launch the activity by discussing with students a life without metals; the effect on society - trains - automobiles, house wares, etc. - everything would have to be made of wood or bone. As we enter the space age, metals become increasingly important and the study of metals their necessity and the research necessary to continue in space, the construction of interplanetary rockets, space stations and landing craft would be unthinkable without an abundance of special metals.

LEARNING ACTIVITIES

1. Check NASA's metals in space rockets - satellites - pictures, etc.
2. Conduct experiments in:
   a. Metal Identification
   b. Hardness of metals
      1. Scratch test
      2. Brinell hardness testing (machine or other test for a. hardness b. toughness c. brittleness, these are some of the important mechanical properties.
      3. Physical properties - include chemical - electrical, thermal, etc.
   c. Bending Tests
      1. Find out by experiment whether the diameter of metal rods or dimensions of beams affect the deflection with a given force.
      2. Do steel and aluminum show the same relative deflections for different diameters.
      3. How does deflection vary with diameter and length of rod.
      4. What diameter is required for an aluminum rod to give the same deflection as a 1/16" diameter steel rod.
      5. Elastic limit:
         determine by experiment how the elastic limit for bending force varies with the length of rod.
   d. Thermal Conductivity
      1. Research thermal conductivity.
      2. Design and perform an experiment to measure the thermal conductivities of different metals. Compare results with those listed in research tests.
      3. Measure coefficient of expansion of various metals and compare results.
      4. Construct bimetal thermostat which when placed over a lamp will turn it on and off intermittently. Use insulated wires and the necessary enclosures so that there will be no danger of shock.

REINFORCEMENT

Use this format in the study and research of all materials.

I. NAME: Aluminum

II. CLASSIFICATION: Non-ferrous metal

III. COMPOSITION AND DESCRIPTION: Aluminum is a brilliant silvery grey metal. It comes from an ore called bauxite. One-sixth of the earth's crust is bauxite. It is rather soft in the pure state and is strengthened by adding other elements to it, such as magnesium and zinc.

IV. PROPERTIES: Aluminum is strong, light in weight, and rust resistant. It bends easy, it works well with hand and machine tools, and is a fair conductor of electricity. It fastens well with screws and rivets, but does not adhere well with solder.

V. USES: Aluminum is used in boats, windows and doors, roofing and siding, landing nets, cooking utensils, pails, water skis, airplanes, automobile engines, wrapping foil and many other items.

VI. MARKET ANALYSIS:

A. Shapes — Aluminum comes in bars, rods, tubes, sheets, wire, I-beams, angles, foil, powder and special shapes for "Do it yourself projects."

B. Sizes: Aluminum comes in all standard sizes and many special sizes.

C. Grades: Aluminum comes in many grades with many different alloys added.

D. Sales Units: Diameter and length of tubing, diameter and length of rod. It also comes by the pound and the square foot.

E. Costs per unit: Costs vary for different grades and alloys.

F. Brands: Alcoa, Reynolds, Kaiser and U. S. Aluminum.

G. Dealers: Local hardware.

VII. MAINTENANCE: Aluminum does not have to be lubricated as it will not rust but care should be taken so it will not become marred, bent or crushed.

VIII. ADDITIONAL READINGS: "The A-B-C's of Aluminum" Reynolds Metal Co., Louisville 1, Kentucky.
"The Alcoa Story" Alcoa Aluminum Co.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

NASA
SP-5010 Selected Shop Techniques
5012 Effects of Low Temperatures on Structural Metals
5017 Metal Forming Techniques
5030 Symposium on Technology Status and Trends
5044 Selected Casting Techniques
5064 NASA Contributions to Metals Joining

TOPIC 8.10 (10-12)

Power is a basis for modern industry. Design is the stepping stone to Development: The development of rockets from the simple ones made by the Chinese to Dr. Goddard's sophisticated beginnings and on to Saturn V has lead to more and more engineering problems of design. The Scientist, Engineer and Technician form the core of the team that has made these developments possible. The fundamentals of materials and structures, drafting and design, mechanical and electrical controls and testing devices can be enhanced by building projects around space projects. Model rockets under proper supervision are safe. The National Association of Rocketry has spelled out a safety code and model rocket engines are available from a number of commercial companies. Both the building of flying and non-flying rockets allow for a wide variety of Industrial Arts concepts to come into play.

LEARNING ACTIVITIES

1. Design and build a model rocket (using prefabricated engines)
2. Analyze power thrust of engines.
3. Design and develop a wind tunnel to test designs.

REINFORCEMENT

1. Design and build a wind tunnel.
2. Design and build a static test stand.
3. Develop instrumentation for the testing devices.
4. Build standard model rockets (commercially available).

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

Model Spacecraft Construction (NASA).
EP-44 Industrial Arts Resource Units

9. Career Guidance

by Project Staff

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Career Guidance

INTRODUCTION

This chapter provides the teacher with ideas, suggestions, and resources with which to create a unit on careers for his students. It is divided into three sections: (1) early grades; (2) four through six; and (3) junior-senior high school. The material was prepared to have utility for all teachers, and particularly for those whose subject matter areas appear in this sourcebook.

The importance of curricular experiences dealing with career concepts can be deduced from the following:

1. A career is a series of vocational decisions made through time. These decisions involve the total individual and each depends upon his decision making ability. This is an emergent skill that must be developed through time contiguous with the maturation process.
2. An analagous situation is seen in the educational career of all students, for an education career is composed of a series of educational decisions made through time.
3. In the current age of science and technology, educational decisions and vocational decisions must not be left to chance; to prescribed or arbitrary placement of students within this or that course of study; or to the persuasions of well-meaning friends, parents, teachers, or supposed "significant others" in the student's environment.
4. Students must be exposed early to the semantics of: work, job, career, positions, job title, pay, play, decision, preparation, qualifications, the role of information, resume, interviews, job satisfaction, work habits, sense of mission, self-knowledge, interest, abilities, aptitudes, skills, talents, strengths, weaknesses, and sources for exploring the world-of-work.
5. The ability to make a realistic career choice is the most significant goal society can set for its educational institutions to provide youth. The best possible education and/or training becomes meaningless unless a person has the necessary sophistication with which to put his education and/or training to work for him.
6. The key for students thinking about a possible career in the Space Age is a continued mastery of the basic fundamentals of science and technology along with an expanding knowledge of the applications of such skills related to possible careers in the future.

THE EARLY GRADES

The outline presented below has five parts: (1) space workers, (2) jobs in space, (3) travelers in space, (4) space ships, and (5) getting ready for a space job. A booklet has been developed to support this outline and is available from NASA for use in the classroom. (EP-31, SPACE JOBS, 1966.)

A. SUGGESTED UNIT

I. SPACE WORKERS
   a. Who works in space jobs?
   b. What do space workers do?

II. JOBS IN SPACE
   a. What job titles do space workers have?
   b. Can you find any books, pictures, or magazines about space workers?

III. TRAVELERS IN SPACE
   a. Who was the first man space traveler? How many astronauts can you name?
   b. Have animals been space travelers? Which ones?

IV. SPACE CRAFT
   a. How much do you know about space craft?
   b. What have space craft been used for up until now?

V. GETTING READY FOR A SPACE JOB (The interested teacher who may wish to read further in the area of the psychology of careers can consult the works of Donald Super, David Tiedemann, or Ann Roe.)
   a. Should you start thinking about the future now?
   b. If you keep adding to what you know about space each year, will it be easier to get a space job in the future if you should want to?

A unit on careers in space for the young student needs to be preceded by a period wherein the student notices pictures on the bulletin board about space, a model of a spacecraft, a satellite, books and fact sheets in the reading corner, and touches, looks, and asks about the objects and related interest stimulated by the various "props" placed in the room.

Introduction to any activity dealing with careers at this level should be light, involving no commitment from the students, and presented in a fashion familiar to established classroom procedures. For example, a game such as: Exploring the Wonderful World-of-Work, would sound immediately in tune, yet contain the key phrase (world-of-work) related to careers that will concern each student throughout most of his life.

B. A TOPIC AND ACTIVITIES

In exploring the wonderful world-of-work certain ideas need attention in order to set into motion the process with which the students will construct their perceptions of careers, career choice, career values, career satisfactions, and, in passing, formulate healthy attitudes towards work itself. For young students, role-play is perhaps the best way of motivating them with respect to learning about careers in space.

Therapists have used role-play techniques with disturbed youngsters for many years. The therapeutic values are especially applicable in terms of diagnostic studies. Role-playing provides too an excellent outlet for the active imaginations of stable youngsters and considerable enrichment experience can be had by the class under the direction of an interested teacher. The key to the high interest generated in role-playing situations is that acting involves no commitment on the part of the individual's inner person. He is playing the part of someone else and thereby can release himself from various day-by-day defenses, restraints, and inhibitions. The caution here is obvious.

TOPIC 10.01

Work is something we all do.

LEARNING ACTIVITIES

(K-3)

Organize a class project to create role-playing situations related to exploring the wonderful world-of-work, for example:

a. Today, I am going to play the part of a space scientist. The space scientist I have chosen to play works in a nice place and knows about what makes a rocket go. My name is Dr. Von Rumple Stilkens and I am in charge of a project to help get people to the moon. I have lots of helpers who are engineers and technicians. I give them drawings I make at my desk about what I think can be done and they build the machines from my ideas. . . . .

b. My part today is one that helps the space scientist. I am Steve Wrench and I can put together anything that the engineer and space scientist want put together. . . . .

c. My part is that of an engineer. My name is Mr. Very Orderly Mind and I work very close with Dr. Stilkens. I know my arithmetic and all about numbers, formulas, drawings of blue prints, and how to put things down on paper so that Mr. Wrench and other good workers know what to do. I can tell the scientist whether his ideas can be made into something that will work. Without me the rockets and space ships and satellites and other machines could not be made.

d. My part is that of Miss Typo and I work for the scientist. I keep his work neat, his appointment book, his meeting times, his travel, and his correspondence, and even get his coffee for him because he generally forgets.

e. My part is Miss Mathematician. I work for the scientist and engineer, and I know how to use the big computer machines and how to read them so that answers can be gotten back to the problems given to me by the scientist or engineer. I like to work with all kinds of numbers, and machines that work with numbers. My work area is clean, air-conditioned and always well-lighted. My work is very important to our space program.

f. Other roles: dietician, space doctor, electronics specialist, truck driver, pilot, astronaut, and so on, can be played by the students.

It is important that each student try acting out several parts for wider experience and to lower the possibility of developing a role-fix syndrome.

CONCLUSION

Career information for the early grades is more or less valueless in terms of the utility it may have for these young people. The important point is to introduce them to thought-producing words early, such as work, play, job, scientiest, engineer and so on. The depth aspects are not to be pressed. If a particular student seems conceptually able to handle more advanced material, he should be encouraged and assisted, otherwise, it is merely exploring "the wonderful world-of-work".

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

MAJOR SECTION REFERENCE

EP-31 - SPACE JOBS, Elementary (K-3) school edition, Peter, Herman J.; Angus, Samuel F.; and Vessells, The Ohio State University in cooperation with the National Aeronautics and Space Administration, 1966.

AUDIO-VISUALS

America In Space (14 min.)

Project Apollo: Manned Flight to the Moon (13 min.)

Shape of Things to Come (21 min.) The teacher may find other film titles listed in other sections of this source book that he may wish to use. Those noted above seem relevant for this section on career guidand for the early grades.

FOR GRADES 4-6

In these grades, it is possible to add some depth to any unit dealing with career guidance activities. Again, no commitment should be forced upon any child in this age group for they still are in the developmental stage where interest patterns are diffuse, and extremely variable. These career choices provide decision-making experiences necessitating research for information with which to substantiate the students career choice.

A suggested unit title might be "Learning About Space Careers." Such a unit could develop into an outline such as follows.

A. LEARNING ABOUT SPACE CAREERS

(NASA's Educational Programs Division has developed a booklet LEARNING ABOUT SPACE CAREERS (EP-32) for grades 4-6, which can be used by the teacher in developing this outline, and is available without charge for each member of the class.)

I. Think About A Space Career
   a. Will space-workers of all kinds be needed in the future?
   b. What steps could be taken now if a person thought he might wish a career in space?

II. Begin to Explore the Space Industry
   a. What is the best way to start an exploration of anything?
   b. Should the class have a committee on resources?

III. Find Out About Jobs in the Space Industry
   a. What is the best way to find out about jobs in any place?
   b. Should the class form into committees to solve the questions?

IV. Determine Pathways and Explore Background for Space Careers
   a. Should the class have a committee on school and community resources on space careers?
   b. What other committees might be formed to help the class learn more about space careers?

V. Making Goals and Keeping Up With Trends
   a. Should we have a Goal Committee?
   b. Should each class member make a folder about his own goals?

B. A TOPIC AND ACTIVITIES

Information is important; without information decisions cannot be made wisely, nor can they be depended upon. There is lots and lots of information. It is necessary to have a plan before gathering information or much of what is gathered cannot be used and much important time is wasted.

TOPIC 10.02

Information is important. (4-6)

LEARNING ACTIVITIES

Make a list of all of the resources one can use to gather information about careers in space science and technology.

Make a plan that will help you to gather information about careers on space science and technology. For example, your plan might have two main headings:

1. General Space Science and Technology Career Information.
2. Space Science and Technology Careers in which I am interested.

CONCLUSION

Experience in gathering and ordering information is an integral part of the elementary school curriculum. Expanding this kind of activity to include occupational/vocational information should prove of value, particularly in terms of junior high school career activities; and as experimental background for the more crucial career planning activities the student will encounter during his senior high school career. Finally, such activity, in view of contemporary "instant" communications of events like launchings of manned and unmanned spacecraft, provides a frame of reference for the classroom teacher to establish relationship between what's going on out there and what's going on in the classroom.

REFERENCES and RESOURCES

Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-32, LEARNING ABOUT SPACE CAREERS, Elementary School Edition (4-6), Peters, Herman J. et. al., The Ohio State University in cooperation with the National Aeronautics and Space Administration, 1966.

AUDIO-VISUALS

THE PLANETARIUM, AN ELEMENTARY-SCHOOL TEACHING RESOURCE, prepared by the University of Bridgeport for the National Aeronautics and Space Administration, 1966. 52pp. (Contains audio-visual bibliography.)

FOR JUNIOR-SENIOR HIGH SCHOOL

The junior-senior high schools have, for the most part, established guidance services. It is, therefore, permissible to depart somewhat from the format used in the previous sections of this chapter. A suggested career unit, including learning activities, is presented for the teacher's reference. This unit may be used for students from grades 7 through 12. Concepts relative to the psychology of careers, interests aptitudes, abilities, can be dealt with by or via the school guidance department.

Boys and girls tend to make tentative career choices during the years in which they move from grade 7 to grade 12. It is time for exploration in depth of the concept of choosing a career. It is not a time for final commitment, but one rather of polishing one's decision making capabilities. In order to enrich this process, information and counseling must be available. Since most schools in this nation have had guidance services in grades 7 through 12 for a number of years, it must be assumed for the purposes of this portion of our Career Guidance chapter that a well organized, and competently staffed guidance service exists at the junior-senior high level. On this basis, it is possible to proceed immediately to a presentation of a suggested unit on careers for students in grades 7 through 12.

SUGGESTED UNIT

This unit is entitled "Seven Steps to a Career in Space Industry." The title permits development of an outline keyed on seven steps as follows:

I. Alert Yourself to a Space Career
   a. What do you know about your Nation's Space Program?
      1. Make a class report on America's Space Program.
   b. What information did your first assignment provide on career opportunities?
      1. Make a class report on the scope of the space industry and the kinds of jobs associated with this work, as well as noting the education and/or training requirements for such careers.

II. Begin to Explore Space Jobs
   a. Prepare a report on one of the following questions.
      1. Who works in space industry?
      2. Where is the space industry?
      3. What is manned space exploration?
      4. What is unmanned space exploration?
      5. What sciences are involved in the space program?
   b. Choose a space career position that appeals to you, then:
      1. Work out a program of study and/or training that is designed to prepare you for your career choice;
      2. Prepare a resume of your education, training, and work experience, as if you were ready to apply for a position;
         a. Your guidance officer is an excellent resource for providing you with insights enabling completion of this assignment.
      3. Keep a copy of your resume, and bring it up-to-date periodically. It is a valuable document.

III. Consider Occupations in the Space Industry
   a. How big is the world-of-work?
      1. Use your guidance office as a source for information on this question.
      2. Use the Dictionary of Occupational Titles, and prepare an outline of the eight major job classification areas.
      3. On the basis of your outline, make a list of space jobs that appear related to one or more of the DOT's classification areas.
   b. What are aerospace technology specialities?
      1. Obtain a copy of "NASA, 20th Century Explorer-A Guide to Careers in Aerospace" from your guidance office or at the nearest first class post office.
      2. Make a list of at least ten groups of occupations in aerospace technology.
      3. Pick an aerospace technology group of interest to you and explore it in depth. Use your research to inform the class about your selected area.

IV. Finding Pathways to a Space Career
   a. Where preparation should begin.
      1. Make a flow chart, or by using some other kind of illustration show your grasp of the dimensions of a career in aerospace technology.
      (Your chart might cover a time period from kindergarten through graduate school into the first career appointment.)
   b. Preparation Specifics
      1. Chart a four year high school course that would qualify you for admittance to most engineering schools.
      2. Chart one for admittance to a top-grade liberal arts college.
      3. Chart one for acceptance by a top apprentice-training school and/or trade school, and/or vocational school, and/or technical school.
      4. Chart one for entrance to most junior colleges.
   c. Where do you fit?
      1. With or without the help of your counselor prepare a four-year course outline for your high school career. Your counselor can help if needed.

d. Is work experience important?
   1. Defend your answer in an open forum type discussion on this topic.
   2. Have committee action occur in terms of surveying the school and community resources relative to providing work experience for high school students.

e. Is a graduate degree essential?
   1. Have class select four members to discuss the pros and cons of this question.
   2. Be prepared to enter into the discussion after the forum and defend whatever position you wish to take on the question.

f. After high school what?
   1. What are some pathways open to you after graduation?
      a. Do a paper on your plans, using the guidance office and other school resources to support your reasoning.
   2. Are space jobs only for men?
      a. Each girl in the class prepare a report on this question.

V. Job Requirements in the Space Industry
   a. Select one of the following questions and be prepared to present a report to the class.
      1. What has been in the newspapers and on TV about space activities this week?
      2. What particular type of workers seemed to be most prominent in this week's space activities?
      3. How did these workers qualify for their jobs?
      4. What requirements do the space workers have to meet in order to get their jobs?

VI. Selecting Goals for the Future
   a. What are Goals?
      1. Plan a discussion on this question.
   b. Should you make a detailed plan?
      1. Prepare a plan for your future.
   c. Are there secrets to success?
      1. List success secrets for home, school, and job.
   d. When should goals be set?
      1. Make a scattergram (during class) from a survey of the class' ideas on this question.
      2. Invite the school counselor to attend this class period and help with the discussion and scattergram analysis.

VII. Your Expanding Horizons
   a. Can you keep up with change?
      1. Be prepared to participate in a discussion on this question.
   b. Is your training preparing you for a lasting career?
      1. Find a definition of career. Your counselor and librarian can help you with this problem.
      2. Using a stimulus question, such as, "What good is a high school graduate today?", be prepared to participate in a discussion on the importance of goals and career planning.
   c. What is the outlook for your career choice?
      1. Prepare a report on this question. If you have no definite career in mind, have your counselor help you set-up a possible career choice based on your present interests.
   d. Can your career fit into the space program?
      1. Assuming your present career choice becomes an accomplished fact, where, if at all, would it fit into the space program?
      2. Prepare a paper on this question (d. 1) and document your facts.

Several generalizations that seem important for career planning relative to the future are:
1. Undergraduate and graduate programs leading to academic degrees in any of the physical sciences or engineering disciplines appear to be suitable foundations for most aerospace specialties;
2. The key to a career in the space age is a mastery of the basic fundamentals of mathematics and science prior to reaching a point of advanced study;
3. A physical scientist or engineer becomes a specialist in an aerospace professional occupation by completing a basic undergraduate curriculum in his chosen field, and by building on this foundation in his later research and development experience;
4. A person with the above background, who is flexible and able to apply his knowledge and skills in any of a number of job situations, should find many opportunities for a career in the space age.

SUMMARY

One charge of the "Great Society" is to provide the best possible education for ALL boys and girls. To insure against producing a society of educated, but undecided adults, it is imperative that career guidance becomes incorporated into curriculum as an integral part of the developmental educational process. The ideas and suggestions in this chapter represent one step in such an endeavor.

MAJOR SECTION REFERENCE

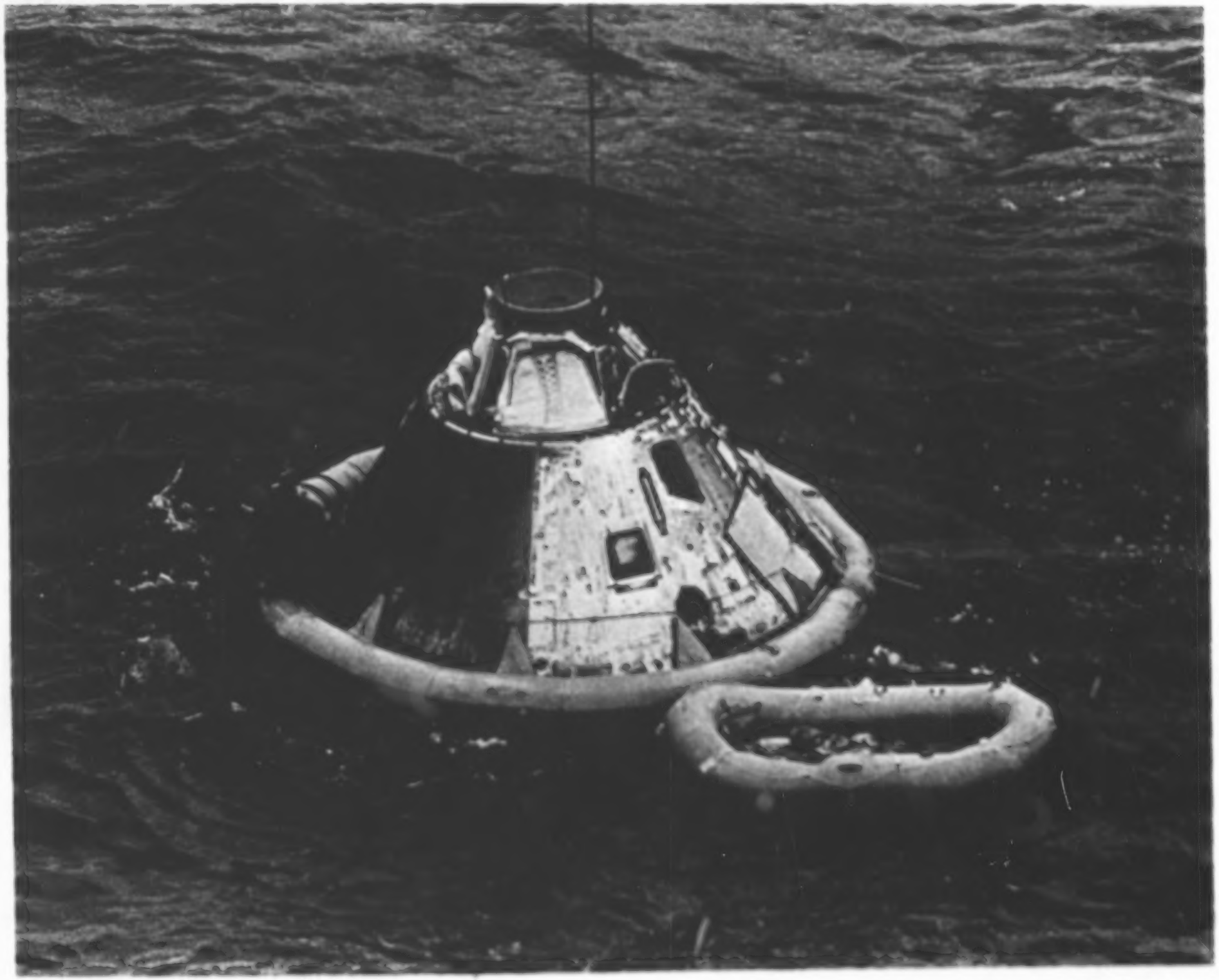
Graded listings of NASA and non-NASA books, periodicals and teaching aids may be found in NASA's Aerospace Bibliography (EP-48).

EP-33, Seven Steps to a Career in Space Science and Technology, High School edition, Peters, Herman J., et. al., The Ohio State University in cooperation with the National Aeronautics and Space Administration, 1966.

AUDIO-VISUAL

Space Science Educational Media Resources, a guide for junior high school teachers, edited by Kenneth M. McIntyre, compiled by the Bureau of Audio-Visual Education, University of North Carolina at Chapel Hill, under support of the National Aeronautics and Space Administration.

National Aeronautics and Space Administration 16mm Film List, including motion picture film library location map and service areas. Free from NASA Headquarters, Media Development Division, Office of Public Affairs, Code FAD-2, Washington, D.C. 20546.



Navy swimmers from Underwater Demolition Team 12, based in San Diego, complete flotation collar attachment on the Apollo 4 shortly after spacecraft landing. The unmanned Apollo 4 which was launched from Cape Kennedy, Fla. and recovered in the Pacific Ocean on November 9, 1967 approximately 275 miles northeast of Midway Island after a highly successful eight and one-half hour heat shield development test.

APPENDIX

Teacher Education

by Project Staff

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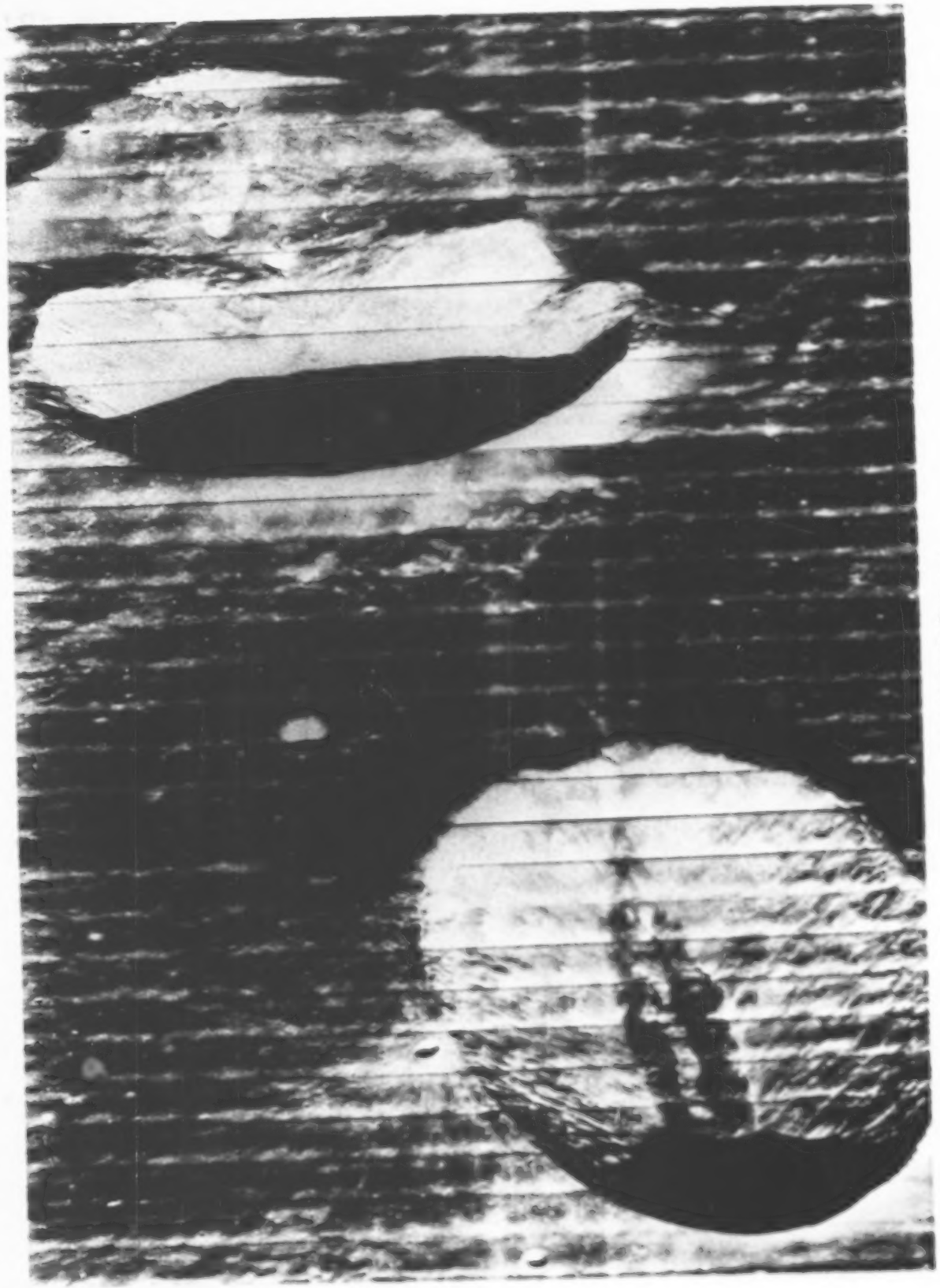


This is a portion of an oblique photograph (top is west) of the lunar surface taken by Lunar Orbiter V on Aug. 10, 1967, when the spacecraft was 60 miles above the lunar surface. This telephoto view shows the elongated crater Messier (lower) and the crater Messier A (top left) at 47° East longitude and 2° South latitude. Messier is about 8 miles long, six miles wide, and about 4,000 feet deep. The material thrown from the crater is readily seen on the floor of the mare (lunar sea) in which both craters are located. Features associated with the movement of loosened rocks and material down the slope of the inner walls can be seen. The crater Messier A is about 8 miles in diameter.

Teacher Education

INTRODUCTION

The Committee in its planning for this guide recognized teacher education as the key to implementing the curricular enrichment processes noted in the preceding pages. From the observations and suggestions it presents in the following paragraphs of this section, the Committee hopes that those responsible for teacher education may obtain ideas and insights which will help them in their efforts to bring understanding of space age developments to pre-service and in-service teachers.

Teacher education, as the Committee sees it, includes programs for both pre-service and in-service teachers, which may be conducted by such agencies as institutions of higher learning, state departments of education, local school districts and professional education associations. When it speaks of bringing understandings of space age developments to teachers, it means understandings not only of their science and mathematics but also of their social and philosophic implications. It means that the teacher education effort should include programs both for the subject matter specialists who wish to broaden their knowledge of their disciplines and for all teachers who believe that understanding of societal change is essential to their professional effectiveness.

The space age is said to have begun with the first Sputniks, Explorers, and Vanguards in 1957 and 1958. Although its flood of research and development studies and projects did not begin to cascade until 1961, it has already provided numerous scientific, technological, and general interest publications and audio-visuals. On the pedagogical side, although there has been the usual textbook lag, the space age has led to the production of an increasing number of syllabi, source books, and curriculum bulletins which provide suggestions for teachers of the several grade levels on ways to integrate space age developments into their teachings. This bulletin represents such an effort.

In addition to these printed and audio visual materials, teacher education programs have found an important resource in the scientists and engineers of NASA, the Department of Defense, and industry, who have shown a gratifying interest in making themselves available, on request, as speakers and discussion leaders. And finally, there has been considerable progress among those responsible for teacher education programs in bringing these resources together to enrich not only the standard undergraduate and graduate science and mathematics courses, but, more particularly, the special programs for in-service teachers, sometimes called "aerospace" or "space science" institutes, courses and workshops.

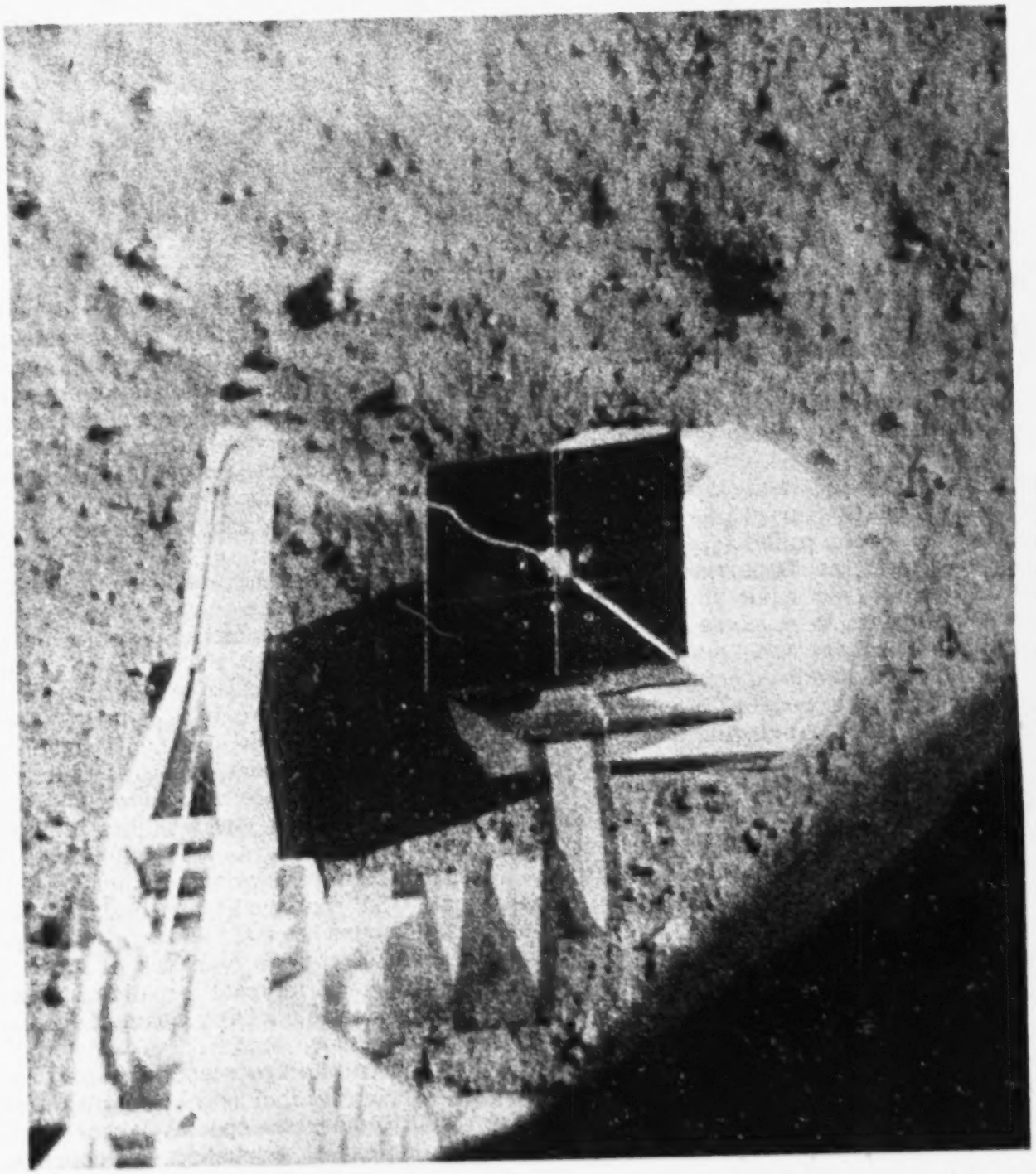
NASA provides many specialized resources and types of direct assistance through its field centers. These resources include NASA publications, films, exhibits, speakers including space science lecturers of the Spacemobile, opportunities for field trips, and assistance in the planning, organizing and conduct of institutes and courses. These sources are provided without charge. NASA does not have funds to provide scholarships for students or monies for sponsoring institutions. Each of NASA field centers maintains an education office to serve its particular geographic region. Contact can be made as described on the inside front cover of this guide.

For those responsible for the standard undergraduate and graduate level science and mathematics courses, NASA, through its education officers at the various NASA centers, can provide consultation on the curricular problems of incorporating space science elements, assistance in obtaining both general and technical Space Science materials of instruction, and information on the availability of guest lecturers and consultants.

Among academic authorities responsible for science instruction in the colleges and universities, the concensus seems to be that the findings of the space sciences can best be introduced into the undergraduate and graduate degree programs through the inclusion of appropriate materials in their standard science and mathematics courses. Few agree that these programs should have added to them a separate course such as Introductory Space Science.

However, for the in-service elementary and secondary school teacher who wishes to bring himself up-to-date with his students' interests the so-called aerospace or space science elective credit and non-credit institutes, workshops, and courses are finding increased favor. Recently, college teachers of science have also expressed interest in updating themselves in the space sciences by means of special non-credit programs.

To schoolmen who are responsible for providing in-service teacher education programs and who wish to undertake special "aerospace" or "space science" workshops or courses, the NASA education officer at the Electronics Research Center may be of considerable assistance. He can organize and conduct such courses. He can help furnish materials of instruction, exhibits, speakers, classroom activities, and field experiences to introduce teachers not only to the subject matter of science, technology, and social implications, but also to the pedagogy of enriching teaching



First "chemistry set" on the moon is seen in this picture taken by Surveyor V's television camera on September 11, 1967. The alpha scattering instrument, which is used to determine the chemical composition of the lunar soil, was deployed to the moon's surface several hours earlier by ground commands transmitted from the Deep Space Network station near Madrid, Spain. The gold and white sensor head, which measures about 7 x 6 x 5 inches and has a circular white skirt on the bottom, was lowered about 30 inches to the surface by a nylon line attached to the bracket at left. The five-pound unit contains six individual radiation sources (Curium 242), which bombard the surface with alpha particles. Radiation detectors in the sensor head measure the energies of the back-scattered alpha particles and protons from the surface. Analysis of [illegible] measurements transmitted to Earth from Surveyor V determined the various chemical elements in the lunar surface material. The "ribbon" attached to the unit and leading to the spacecraft is a flat cable carrying power to the instrument and data from the detectors back to the spacecraft telemetry system.

with it. In succeeding pages of this section are discussions of space science institutes, workshops, and courses and sample outlines of their programs.

The "aerospace" or "space science" programs range in form from the one or two day non-credit institute and the one or two week non-credit drive-in workshop to the two or three week credit-bearing workshop and the semester course. They may be conducted in the summer months, or in the after-school hours of the school year. They are colorful, and they stimulate considerable student interest and professional activity. They possess the staff, the instructional materials, resources, and the organizational flexibility to provide to all their students a general over-view of space age developments; to those who so desire they often furnish an opportunity to pursue a special interest in depth.

In the light of the immediate task of bringing space age understandings to children in our schools today, the Committee recommends these "aerospace" or "space science" institutes, workshops, and courses as proper vehicles of in-service teacher education.

The following paragraphs discuss a number of questions raised by summer session administrators concerning these "aerospace" or "space science" special programs, such as those dealing with problems of standards, staffing, and finance.

STANDARDS

Among the questions raised concerning standards are those related to (1) credit structures, (2) bases for grading, and (3) admissions.

1. With few exceptions, education rather than science credit is offered to students who complete the introductory course. Because the "aerospace" and "space science" workshops and courses call for the student's creative application of his background of training and experience to the selective integration of a new field of human experience into his teaching, graduate credit can be justified. Because these courses are in most cases introductory, their science and mathematics are quite elementary. However, science departments permit students to earn graduate science credit providing the instruction has the quality and the schedule the flexibility to permit students to pursue their areas of scientific interest with profit.

These workshops or courses have often permitted the student to earn two semester hours of credit for a two-week, 45-hour workshop; three semester hours for a three-week, 60-hour workshop or two semester hours for a six-week, 30-hour course. The two-week workshop seems to have considerable appeal to the professionals who, having completed degree and certification requirements, wish to keep up to date by occasionally enrolling in summer courses. In recent years, however, colleges and universities have tended to discontinue two-week, credit-bearing workshops and offer nothing shorter than three-week workshops.

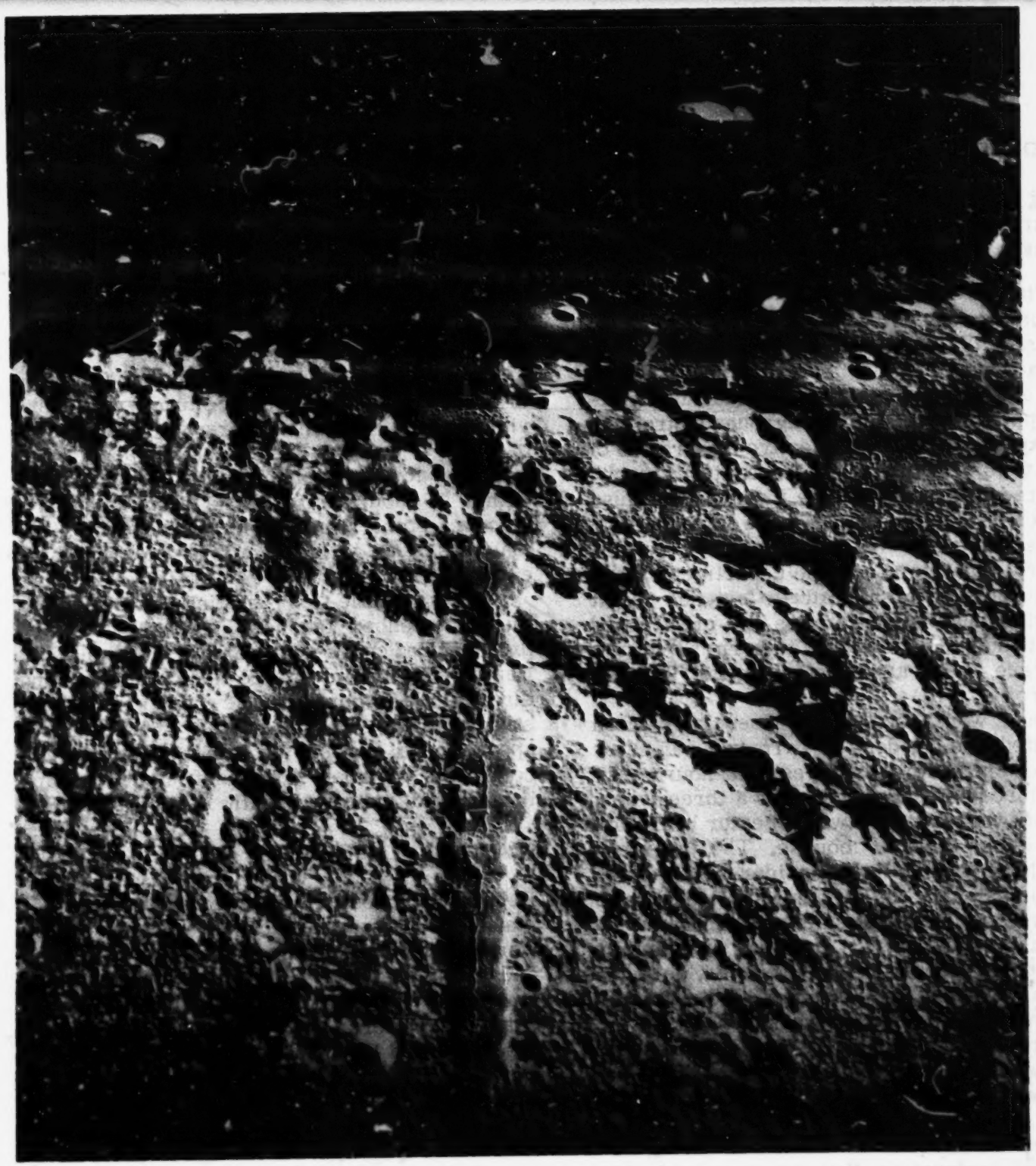
2. Grading requirements in these courses and workshops usually call for the student to submit an end-of-course project that synthesizes what he has learned in the course into a material of instruction that he can use in his teaching. At some institutions of higher learning, student projects of these "aerospace" and "space science" programs have been published and have elicited state, region, and even nation-wide interest among teachers. In addition to requiring an end-of-course project, some instructors administer written tests.

3. Admission to these workshops and courses is often limited to in-service teachers, supervisors, and administrators who hold their bachelor's degree. Exceptions are sometimes made to admit experienced teachers who are within 15 hours of earning their bachelor's degree. Some courses have required that teachers have at least two years of teaching experience.

The rationale for limiting enrollment to the experienced teachers is that these are professional courses in which discussion about implementation of space-age understanding through classroom practice and curriculum structure take on the nature of the clinical approach to the subject; the questions and comments of those with insufficient teaching background interfere with such discussion.

STAFFING

Related to questions of standards is that of staffing. The aerospace or space-science workshop, with its numerous guest speakers and guest resource consultants, its exhibits, materials of instruction, and field trips, its changing pattern of large and small group meetings and discussions, is a complex, difficult-to-plan, administrative operation. Most workshop programs have a staff of at least two and sometimes three professionals, i.e., a director and one or two associates. They are chosen to provide an instructional capability that includes understanding both of aerospace science and technology developments and of elementary and secondary school curriculum practices. At least one of the staff, usually



This photograph was taken by Lunar Orbiter V of site V-25 in its mission to photograph selected scientifically interesting areas on the front and far side of the Moon and supplemental photography of candidate Apollo sites. This frame was taken by Orbiter V's 80mm focal length wide angle camera. The area shown is the Alpine Valley which is located at approximately 48° 55 mins. North latitude, 3° 00 mins. East longitude and is situated between Mare Frigoris and Mare Imbrium. The mean lunar distance across the photograph is approximately 286 miles. When viewed with the band of edge data at the left, North is approximately at the right and the Sun is at the bottom at an angle of approximately 16.2°. This photograph was taken on August 14, 1967 and relayed to the Madrid station of the Deep Space Network on August 23, 1967. Lunar Orbiter V was at an altitude of 153.5 miles when it took the photograph.

its head, possesses the earned doctorate; seldom is a staff member employed who holds only a bachelor's degree. Institutions conducting these workshops generally find it necessary to engage one or two guest faculty members. However, most of these schools appoint a member of the resident faculty as the responsible head of the program; sometimes this person is given the title of director, sometimes resident director, sometimes chairman of the planning committee.

Although authorities at institutions of higher learning occasionally bring to their campus as guest directors highly competent men and women to serve as the responsible heads of their "aerospace" or "space science" workshops and courses, NASA's education officers, by policy, advise against such practice. The NASA position is that a college or university should not undertake such a program unless it has a knowledgeable, interested, and highly competent staff member capable of undertaking the necessary advanced planning and promotion and of taking full control of the operation and full advantage of its possibilities. Involving, as it does, administrative and management elements that are sometime institution-wide and public relations implications that include not only the community but sometimes the state and nation, it should not be placed in the hands of an outsider.

The responsible head of an "aerospace" or "space science" workshop is usually appointed from the sponsoring institution's faculty. Assistant or associate directors are drawn from either the institution's faculty or from the teaching or administrative staffs of public elementary or secondary schools. Those employed from outside the institution are usually people who have had experience with introducing aerospace or space-science elements into school programs. They provide both know-how and confidence to students who, because they are confronting a new and highly important field of human endeavor, may be concerned about their ability not only to comprehend what they are being taught but also to translate it into teaching.

FINANCE

This section might equally well have been labeled "support," "promotion," or "workshop size." The nature of the problems included can be sensed from such contrasting statements by summer session administrators as the following: "We have had great aerospace workshops for the past three or four years, but we can't seem to attract more than 17 or 18 students. We can't afford to continue." And, "For the last two or three summers we have enrolled more than 100 students each summer. The workshops are financially very successful; the students are enthusiastic; but our academic authorities feel that the enrollment should be reduced if the university graduate, professional standards are to be maintained."

Although there are no clear-cut answers to the problems implied in these comments, the observations that follow may prove helpful to the summer session administrator:

Workshops or courses with two or three faculty and 30 to 50 students seem to elicit the most positive expressions of satisfaction. Some workshop directors of considerable experience strive for 45 to 50, but not more than 50 students; others aim for 35 to 40 students, but consider any number over 40 as too large. Because these workshops or courses are often limited to in-service teachers and tend to draw professionals with considerable experience, a group of 30 or more students enriches the program and allows for a wider sharing of ideas and livelier small-group discussion. With a group of more than 45, the consensus seems to be that communication between staff and students and among the students themselves tends to break down. On the other hand, there are two or three colleges which for a decade or more have have been conducting aerospace workshops of 75 or more students and have worked out organizational formulas for maintaining high standards of instruction with large groups.

As to expenses to the college or university which conducts an aerospace workshop, it was pointed out on a preceding page that NASA provides many printed and audio visual materials of instruction without cost except for minimal film shipping charges; that the services of consultants and speakers from NASA and, frequently, from industry are without charge; and that NASA Spacemobile lecturers serve at no cost. NASA also provides exhibits at minimal expense. The cost of field trips to NASA field installations may be charged to students; often this cost is low because of the generosity of nearby Air Force or Naval Aviation installations which provide transportation. Occasionally, airlines also provide, gratis or at reduced costs, transportation for workshop field trips. The principal expenses to the college are those for salaries, usually of two or three professionals, for advertising and promoting the workshop, and for expenses of entertaining guest speakers and guest faculty.

Television picture from United States' spacecraft Surveyor VI shows rough terrain near the landing site in the Moon's Central Bay (Sinus Medii). Surveyor landed at 5:01 p.m. PST November 9, 1967, after a 65½-hour flight from Cape Kennedy. The heavily-cratered area appears to be absent of rocks with the exception of the small object casting a thin shadow at lower right.

One fact has become increasingly evident to those who have been associated with aerospace workshops: these workshops must be vigorously promoted unless they are the recipients of special financial support or the beneficiaries of selective student scheduling and advisement. In spite of their obvious color and student appeal, they do not as a rule attract students unless they are actively and imaginatively publicized.

The reason for this apparent anomaly has been frequently discussed among aerospace workshop directors and summer session administrators. The most reasonable explanations seem to be that they are elective professional courses for which graduate students are often permitted only a limited number of credits and they are not in the category of elementary and secondary school methods courses. The younger, degree-seeking graduate students, therefore, do not automatically gravitate toward them.

EXAMPLES OF SPACE SCIENCE INSTITUTES, WORKSHOPS, and COURSES

Following are samplings of different types of institutes, workshops and courses which have been conducted successfully for in-service teachers. They range from one and two-day institutes to the full semester course.

ONE DAY SPACE-SCIENCE INSTITUTE

9:00 - 10:00	The Implication of the National Space Program to Education
10:15 - 11:30	Spacemobile lecture-demonstration
11:30 - 12:00	Question and answer period
1:30 - 3:00	Panel discussion: "Space Education in the Classroom" Institute Director, Elementary School Teacher, Jr. High School Teacher, Senior High School Teacher, Spacemobile Lecturer

TWO DAY SPACE-SCIENCE INSTITUTE FOR TEACHERS

FIRST DAY

9:00 - 10:00	NASA philosophy of space exploration: (a) Objectives, (b) Goals, and (c) Research - a talk with discussion Texts: "Spacecraft" and "Projects: Space".
10:15 - 11:45	Spacemobile lecture-demonstration-explanation of individual models, followed by discussion
1:00 - 2:00	Implications of space exploration to education--Educational Programs Division presentation
2:00 - 3:00	Film: Mastery of Space or Friendship 7

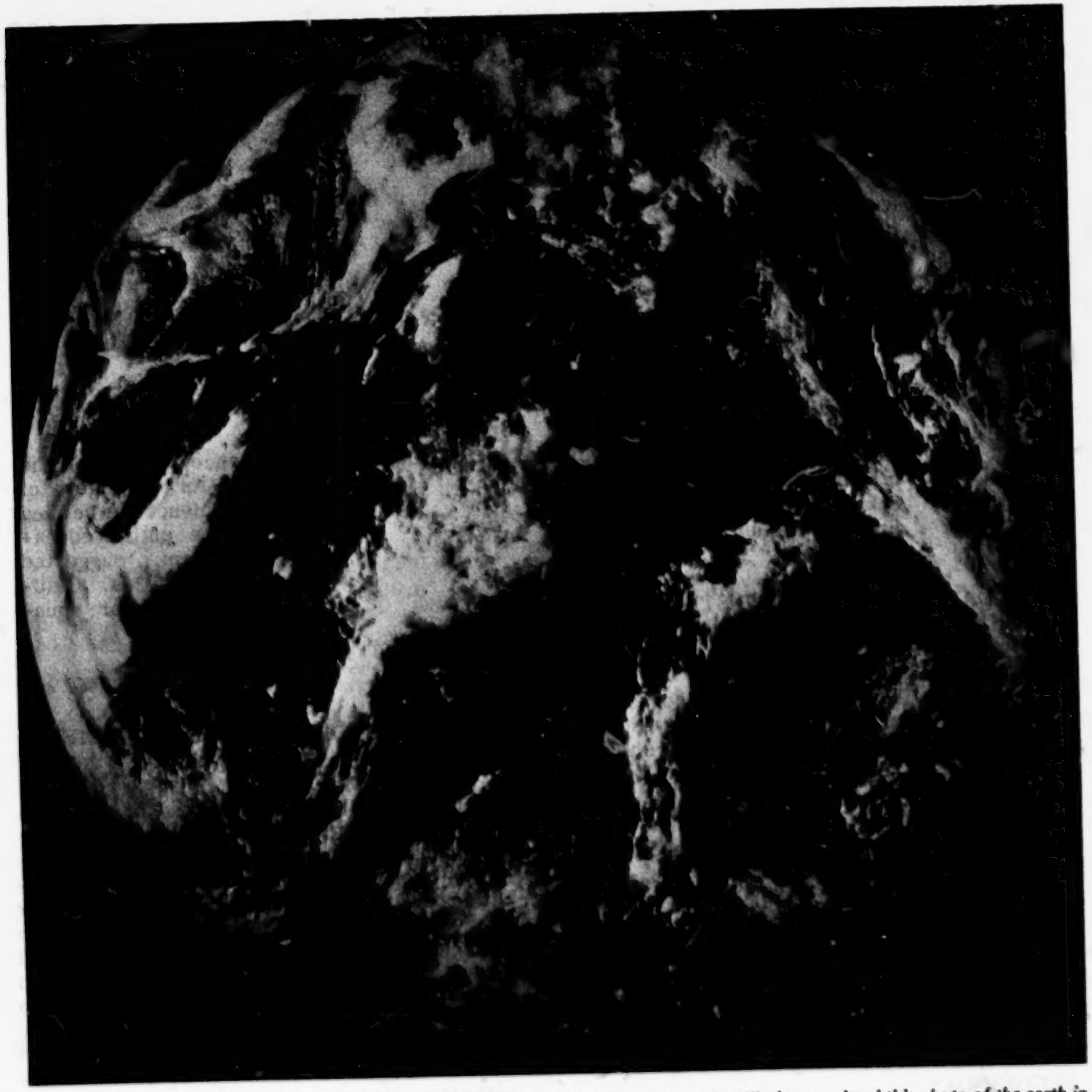
SECOND DAY

9:00 - 10:00	Astronomy-Basic overall picture of the science of astronomy and its relation to the space program Text: Challenge of the Universe
10:15 - 11:45	Space science education in the curriculum-An overview of how space science can be used to enrich the entire educational program. Suggested classroom activities. Guidance information for counseling.
1:00 - 2:00	Resources
2:00 - 3:15	Discussion and summary

ONE WEEK DRIVE-IN SPACE SCIENCE WORKSHOP

The Educational Programs Office of the NASA Electronics Research Center has developed a plan and flexible guide for a one-week "Drive-In Summer Workshop Program." Teachers within a fifty mile radius are informed that the NASA will be conducting a space science workshop at a certain place at designated times and dates. Interested teachers can drive-in and participate in a general session on the first day and return one other day during the week for workshop activities in their particular discipline. The second day's activities include presentations and specific demonstrations performed by the lecturers and teachers to illustrate space science concepts that can be applied to the classroom.

The drive-in plan can be used for summer workshops or adapted for in-service programs during the academic school year.



The ATS-III (Application's Technology Satellite) transmitted this photo of the earth in color, back to ground stations on November 10, 1967. Four continents (portions of North and South America, Africa, and Europe, and the Greenland ice cap) can be readily seen while the Antarctic continent is blanketed under cloud cover. Major weather over the central United States, stretching from the Great Lakes to Mexico, represents a cold front moving eastward. A tropical storm (bottom center), with a cold front extending into Argentina, can be seen.

MONDAY

General Session: All participants of the workshop should attend Monday's classes.

9:00 - 10:00 Spacemobile Presentation: This presentation will acquaint teachers with the overall space program.

10:00 - 10:30 Break: During break, teachers will be able to inspect the models used in the science demonstration and formulate questions.

10:30 - 11:15 Question and answer period about lecture materials.

11:15 - 12:00 NASA Educational Program

12:00 - 1:00 Lunch

1:00 - 2:00 Lecture: "The Role of the Teacher in the Space Age". This lecture will point out to teachers that concepts and ideas have changed drastically with the advent of space exploration. It will indicate how teachers can adapt these ideas to enrich their teaching in all areas.

2:00 - 3:00 Film: Contact NASA for latest film survey of space programs.

3:00 - 3:30 Questions and Answers

TUESDAY

English and Social Studies Teachers: This session will be devoted to relating space science concepts for English and social studies teachers.

9:00 - 10:00 Lecture: "The Role of the Humanities Teacher" Space achievements have effected great changes in what people believe and how they think. It is the responsibility of the humanities teacher to prepare the students for life in the space age.

10:00 - 10:30 Break: During the break, teachers will have an opportunity to review and look at literature from NASA and current literature from local libraries.

10:30 - 11:00 Film: "Ariel" (13 min.) This film will show that the exploration of outer space is an international program with international social implications.

11:00 - 12:00 Motivational Aids for the English teacher: This portion will deal with suggested ideas of how the English teacher can motivate students through their natural curiosity in space exploration through: A. Vocabulary - new words, use of combination words, spelling lists; B. Written expression; C. Oral expression - panel discussions, debating topics, dramatics; and D. Languages around the world.

12:00 - 1:00 Lunch

1:00 - 2:30 Motivational Aids for the Social Studies Teacher: This portion will deal with suggested ideas of how the social studies teacher can motivate students through their natural curiosity in space exploration by calling attention to: A. Many nations will cooperate with the U.S.A. in its scientific space studies. Unit of study could be worked around the international cooperation of nations; B. Tracking Stations--Countries around the world are aiding in the tracking of satellites. This involves international cooperation; C. Tiros Weather Satellite -- Weather plays a vital role in how people live and how they make a living; D. Maps--Space exploration is changing concepts of map reading. The true shape of the earth can be determined by satellites; and E. Communication satellites-- Because of the communication satellites, our world has grown smaller. People must, of necessity, learn more about each other's cultures.

2:30 - 3:00 Summary of the day's program.

WEDNESDAY

Earth Science and General Science Teachers: This section will be devoted to teachers of earth science and general science. There will be discussions of the new concepts and knowledge brought about by the exploration of space.

9:00 - 10:00 Lecture: "The Role of the Earth Science and General Science Teacher" What happens in outer space vitally affects concepts that are taught in earth science and general science.

10:00 - 10:30 Break: During the break, teachers will have the opportunity of checking the latest NASA references pertaining to earth science and general science.

10:30 - 11:00 Film: "Universe" (28 minutes). This is an animated film about the Solar System and the galaxies.

11:00 - 12:00 Lecture: "The Moon's Geological Importance" The moon may explain the geological formation of our own earth.

12:00 - 1:00 Lunch

1:00 - 1:30 Lecture: "Determining the Composition of the Lunar Surface" Models will be used to show how this is done.

1:30 - 2:30 The use of Satellites to Study our Earth: A. Earth oriented satellites (OGO); B. Determining shape of earth (Vanguard); C. Recording accurate distances (Navigational satellites). Lecture and discussion.

2:30 - 3:30 Detection of Living Organisms on Planets: A discussion of devices used for this purpose.

THURSDAY

Biology, Physics, Chemistry, and Mathematics Teachers: Space exploration has shown that all sciences are dependent upon each other.

9:00 - 10:00 Lecture: "The Role of High School Science Teachers" An explanation of how space research will affect the teaching of science in the future.

10:00 - 10:30 Break

10:30 - 11:00 Aids to High School Science Teachers: This time period will be used for a discussion of materials that will aid high school science teachers. For example, NASA publications, film lists, and ideas for Science Fair projects.

11:00 - 12:00 Lecture: "Physics for the Space Age" The lecturer will discuss some of the areas currently being taught in physics. For example, sound, optics, electricity, and heat.
Film: "Electric Power generation in Space." (26 1/2 min. color)

12:00 - 1:00 Lunch

2:00 - 3:00 Lecture: "Space-oriented Mathematics Concepts" Examples of what might be discussed are: A. Conic sections, relating them to orbits; B. Calculation of distance; C. Calculations of time; and D. Calculations of heights of objects (trigonometry)
Film: "Space Navigation." (21 min., color)

FRIDAY

Elementary Teachers: This session will be devoted to aiding the elementary teacher to incorporate space concepts into the curriculum.

9:00 - 10:00 Special Spacemobile Demonstration: This will not be a typical Spacemobile demonstration, as its purpose will be to relate selected NASA programs to the elementary school curriculum.

10:00 - 12:00 Construction of Teaching Aids to Demonstrate Space Science Principles: Construction of A. Action/reaction aid; B. Device to explain orbits; and C. Model Solar System.

12:00 - 1:00 Lunch

1:00 - 2:00 Develop a Unit Using Satellite as a Central Theme: Tiros, a weather satellite, could be used as a theme for this unit.
Social Studies: Map reading; Locating tracking stations; Cooperation with many countries.
English: letter writing; vocabulary; spelling; drama
Mathematics: temperature changes; distance; longitude and latitude.
Art: Making charts; Making models of types of clouds; Making diagrams; Painting satellites; Designing satellites; Individual creative impressions.
Music: Songs about weather; Space records.
Science: Devices built to demonstrate weather prediction.
Physical Education: Games depend upon weather. Film: "Tiros" (13 min.) This film will show how it is possible to predict weather with a satellite.

2:00 - 3:00 Making Models of Satellites, Probes and Rockets: We will show how to construct: (a) Sputnik (tennis ball and wire); (b) Tiros (tin can and wire); and (c) Rockets (paper tubing).

ONE WEEK SPACE SCIENCE WORKSHOP FOR ELEMENTARY TEACHERS

MONDAY

1:30 -	1:45	Preview of the Workshop and Briefing on the Missions of NASA
1:45 -	2:45	Spacemobile Space Science Lecture-Demonstration
2:45 -	3:00	Break
3:00 -	3:15	Question and explanation session.
3:15 -	4:30	"The Elements of Aeronautics and Astronautics"

TUESDAY

1:30 -	2:15	Suggested student activities in the area of aeronautics and astronautics
2:15 -	3:00	"An Inquiry Approach to the Teaching of Space Sciences"
3:00 -	3:15	Break
3:15 -	4:30	"Milestones in Astronomy"
Evening		"The Night Sky"

WEDNESDAY

1:30 -	2:15	Suggested student activities in the area of elementary astronomy
2:15 -	3:15	"Safe Rocket Experiments for Students"
3:15 -	3:30	Break
3:30 -	4:30	Workshop Participant Activities

THURSDAY

1:30 -	2:30	"Human Factors in Space Exploration and Exobiology"
2:30 -	2:45	Break
2:45 -	3:45	Suggested student activities in the area of biology in Space exploration
3:45 -	4:30	Workshop participant activities

FRIDAY

1:30 -	2:20	Spacemobile Space Science-Lecture-Demonstration
2:20 -	2:30	Break
2:30 -	3:30	"Mathematics in Space Exploration"
3:30 -	4:15	Suggested student activities in the area of mathematics for the space age
4:15 -	4:30	Evaluation of the workshop

Workshop Participant Activities:

1. Previewing NASA Films: All NASA films used for free distribution to teachers are available for previewing.
2. Evaluating Aerospace Science Educational Publications: All NASA educational publications plus many obtainable through National Aerospace Education Council are available.
3. Performing Aerospace Related Experiments: 100 procedures for aerospace experiments or activities are available.
4. Workshop Participant Projects: Participants are encouraged to develop special lessons or apparatus for teaching an aerospace-related topic. Suggested procedures and background information for a couple of dozen such projects are available.

TWO WEEK SPACE SCIENCE WORKSHOP

This two-week space science workshop has been planned with the following aims and purposes: (1) To provide the teacher with up-to-date space-science information; (2) To provide the teacher with resources and their evaluation; (3) To adapt these resources for use in the classroom; (4) To stimulate and motivate the teacher to continued study and application of space science.

The class will meet three hours per day on Monday through Friday for two weeks, a total of 30 hours. Approximately two hours per day will be devoted to formal presentations. The remaining time will be devoted to the following: (1) Previewing films (minimum, five per group); (2) Working in assigned groups to develop projects suitable for classroom presentation (minimum, two per group); (3) Individual group presentations of selected projects to class during the last week (15 minutes each); (4) Performing individual activities or experiences (five per student).

MONDAY

9:00 - 9:30	Introduction
9:30 - 10:30	"The Aims and Objectives of the Workshop"
10:30	History of Space Exploration
11:00 - 12:00	Formation of groups and activity planning

TUESDAY

9:00 - 10:00	"The Earth in Space": dimensions, nature, and relationship in the universe
10:00 - 11:00	"Our Sister Planet, the Moon": dimensions, nature and importance
11:00 - 12:00	Workshop activities

WEDNESDAY

9:00 - 10:00	"The Solar System": dimensions, environments, and dynamics
10:00 - 11:00	"The Sun": characteristics and related phenomena
11:00 - 12:00	Workshop activities

THURSDAY

9:00 - 10:00	"The Stars": characteristics, magnitude, and types
10:00 - 11:00	"The Milky Way and Other Galaxies"
11:00 - 12:00	Workshop activities

FRIDAY

9:00 - 12:00	"The Tools of the Astronomer": the universe, its behaviors, spectra, and time-distance; planetarium presentations

MONDAY

9:00 - 10:00	"Frontiers of Space": Space-mobile lecture-demonstration
10:00 - 11:00	"What Makes A Rocket Go?" film presentation and discussion
11:00 - 12:00	Workshop activities

TUESDAY

9:00 - 10:00	"Satellites and Space Probes"
10:00 - 11:00	"Manned Space Flight"
11:00 - 12:00	Workshop activities

WEDNESDAY

9:00 - 11:00	Field trip

THURSDAY

9:00 - 10:00	Review and Evaluation of Field Trip
10:00 - 11:00	"Space Biology: Life in Space"
11:00 - 12:00	Workshop activities

FRIDAY

9:00 - 10:00	"Men to the Moon and Beyond"
10:00 - 12:00	Presentation and review of projects

THREE WEEK SPACE SCIENCE WORKSHOP

This three-week aerospace education workshop has been planned with the following aims and purposes: (1) To provide the teacher with up-to-date aerospace information; (2) To provide the teacher with resources and their evaluation; (3) To adapt these resources for use in the classroom; and (4) To stimulate and motivate the teacher to continued study and application of aerospace education.

The class will meet five hours per day, Monday through Friday.

Approximately three hours per day will be devoted to formal presentations. The remaining class time will be devoted to the following: (1) Previewing films (minimum, five per group); (2) Working in assigned groups developing projects suitable for classroom presentation (minimum, two per group); (3) Individual group presentations of projects to class (15 minutes maximum presentation on each project); and (4) Performing individual experiments (minimum, five experiments per student).

FIRST WEEK

Monday

Orientation to the Aerospace Concept and to the Role of NASA. Major Objective of the Work-shop-The teacher assumes a leadership role in the community for aerospace education: (1) The importance of aerospace education in the curriculum; (2) What teachers are expected to take away from this workshop in terms of aims, objectives, concepts, teaching aids, and projects; (3) The role of NASA Space-mobile; and (4) Formation of groups and beginning of project development.

Tuesday 1st hour	"Air, What Is It?" Air through the eyes of a pilot. Discussion of social law, FAA rules, etc.
2nd hour	"Atmosphere and Space": Through the eyes of a politician, economist, meteorologist, chemist, physicist, and teacher. The teacher discussion includes fluids in general, air in particular, weight to mass, the real meaning of temperature, and the results of air movement.
3rd hour	"Atmosphere and Space" (cont.): Application of air to the airplane, wind tunnel, kite, airfoil, propellers, helicopters, paragliders, and new aircraft design, M-2.
Wednesday 1st hour	"From Air to Space": An overview of arbitrary limits of earth spheres.
2nd hour 3rd hour	"How Man and Machines Adjust to the Extreme Conditions of High Altitudes.
Thursday 1st hour	"Space Geography": Discussion of the outstanding characteristics of each planet.
2nd hour	"The Moon and the Stars": What is it like on the moon? Where did it come from? Why go there in the first place? What are the basic properties of stars, their identification, and location?
Friday	"Basic Physical Principles Involved in Air and Space Travel": A seminar including the film "What Makes a Rocket Go?" Emphasis upon the basic physical principles enunciated by Galileo, Kepler, and Newton.

SECOND WEEK

Monday	Basic Mathematical Principles Involved in Aerospace: A discussion of the few very necessary mathematics concepts used in aerospace. The basic text of this discussion will be "What's Up There?
Tuesday	Field Trip
Wednesday	Aerospace Education in the Classroom-- "Our Total Environment--Our Universe"
Thursday	A.M. Continuation of Wednesday's discussion.
Friday	Field Trip

THIRD WEEK

Monday	"Life Science in a Space-age Setting (Exobiology)"
Tuesday	"History of Space Exploration and the Arts (Art, Literature, Theatre)," "Socio-Economic Implications," "Practical Applications of Space Exploration"

Wednesday	"The Planetarium"
Thursday	Space-science enrichment, Motivational aids for the teachers
Friday	Culmination of Workshop: Progress reports on teacher projects; workshop luncheon; summary.

SEMESTER COURSE OUTLINE

Introduction to Astronautics and Its Applications.

I. History of Astronautics
   - A. Chinese Rockets
   - B. Arab Rockets
   - C. Roger Bacon
   - D. Sir William Congreve
   - E. Literary Voyages in Space
   - F. Konstantin E. Tsiolkovsky
   - G. Robert E. Pelterie
   - H. Herman Ganswindt
   - I. Robert H. Goddard
   - J. Hermann Oberth
   - K. Walter Holmann
   - L. Wernher von Braun
   - M. Modern Period

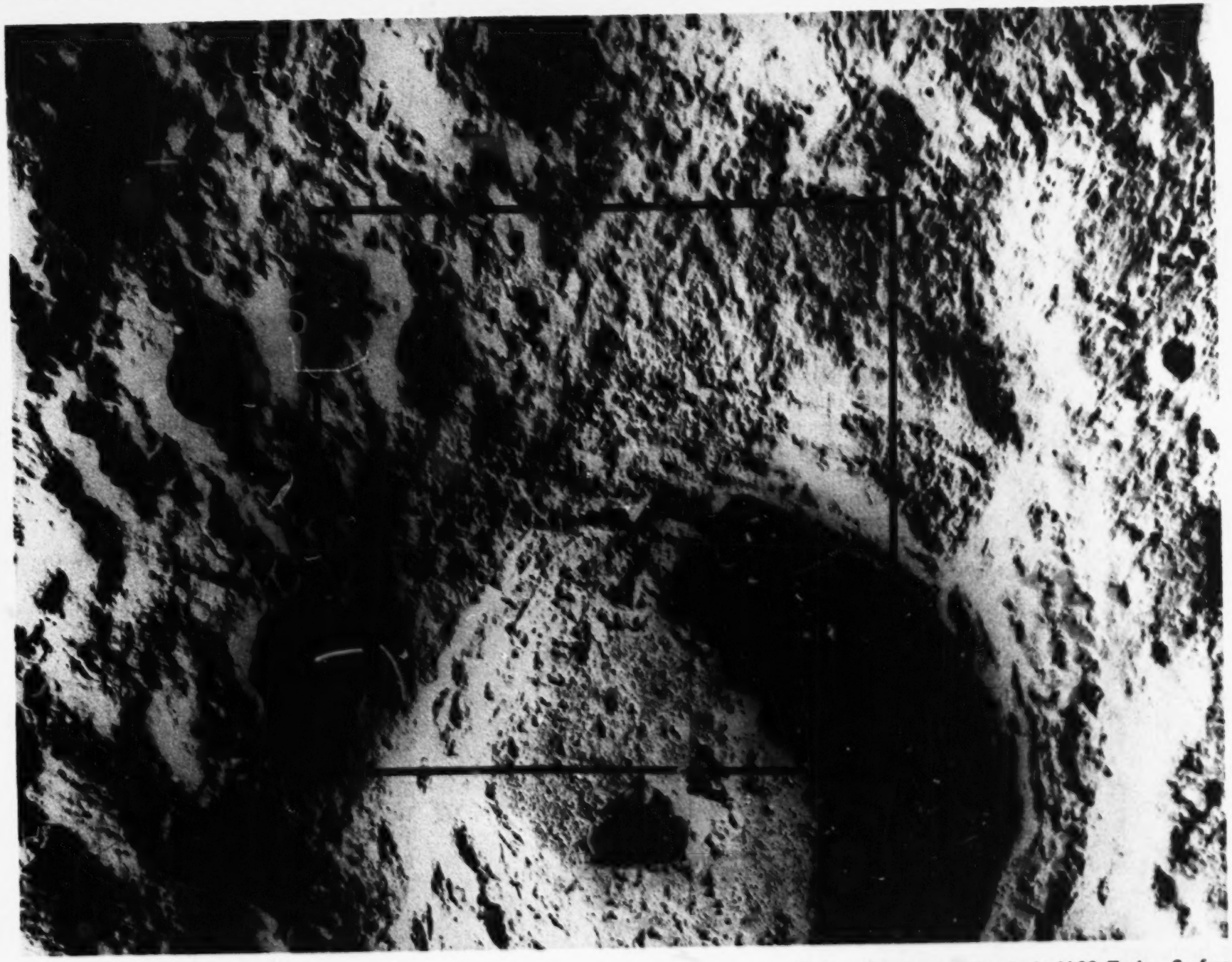
II. The Objects of Space Exploration
   - A. The Moon
   - B. The Solar System: planets including the earth, asteroids, meteors, comets
   - C. The Galaxy and beyond

III. Space Environment
   - A. Solar System
     1. Origin of the Solar System
     2. Inner planets
        - a. Mercury
        - b. Venus
     3. Other Planets
        - a. Mars
        - b. Jupiter
        - c. Saturn
        - d. Uranus
        - e. Neptune
        - f. Pluto
     4. The Sun
     5. The Moon
     6. Asteroids
     7. Meteorites, Micrometeorites, and Dust
     8. Comets
     9. Radiation and Fields
   - B. The Earth
     1. Form and size of the earth
     2. Rotation of the earth
     3. The earth as a satellite of the sun
        - a. Newton's law of gravitation
        - b. Newton's first and second laws of motion
     4. The effect of earth's inclined axis
     5. Locating places on the earth's surface
     6. Measuring time
     7. The earth's atmosphere
        - a. Composition
        - b. Pressure
        - c. Zones of the atmosphere
        - d. Weather elements
     8. The moon as a satellite of the earth
   - C. Beyond the Solar System

IV. Atmospheric Flight
   - A. Basic Principles
     1. Lift and Weight
     2. Thrust and Drag
     3. Stability and Control
   - B. Propulsion Theory
     1. Propellers
     2. Jet Propulsion
     3. Rocket Propulsion
   - C. Subsonic Aerodynamics
   - D. Supersonic Aerodynamics
   - E. Hypersonic Aerodynamics

V. Principles of Rocketry
   - A. Application of Newton's Laws
     1. Action-Reaction
     2. Motion
   - B. Inertia - concept of momentum and force
   - C. Gravitation
   - D. Centrifugal force
   - E. Types of Rocket engines
     1. Chemical Propulsion
        - a. Basic gas laws
        - b. Liquid propellants
        - c. Solid propellants
     2. Nuclear Propulsion Systems
        - a. Atomic forces
        - b. The reactor
     3. Other Propulsion Systems
        - a. Ion Rocket (Electrostatic)
        - b. Plasma Rocket (Electromagnetic)
        - c. Photon Rocket
        - d. Solar Soil
     4. Nuclear
     5. Electric
   - F. Rating Rocket Engines
     1. Thrust
     2. Specific Impulse
     3. Exhaust Velocity
   - G. Rocket Vehicle Design
     1. Clustering Engines
     2. Staging
     3. Airframe Design and Construction
     4. Materials
     5. Storage of Propellants
     6. Pumping Propellants
     7. Aerodynamic Stability

VI. Celestial Mechanics
   - A. Universal Law of Gravitation
   - B. Elements of Planetary Motion
   - C. Kepler's Laws
   - D. Orbits
     1. Circle
     2. Ellipse
     3. Parabola
     4. Hyperbola



The area shown in this wide angle view of the lunar surface is site V-30, Tycho. Surface feature detail as small as 122.8 feet across can be seen in the original of this photograph. This frame is a part of the six frame sequence of this area taken by Lunar Orbiter V Aug. 15, 1967. Four of the corresponding telephoto frames were mosaiked to form a 5 by 5 foot panoramic view of that portion of this photograph which is outlined in black. Surface features as small as 15.3 feet across are visible in these mosaics. These photographs are an improvement over previous Earth-based lunar photography and are expected to provide scientists with valuable information regarding the geologic structure and probable origin of the Moon. The coordinates of the center of this photograph are approximately 41°50'S latitude and 11°30'E longitude. Lunar Orbiter V was at an altitude of 133 miles when this photograph was taken.

E. Trajectories and Perturbations
F. Free Fall
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